

Concrete

Vol. 23

Detroit, July, 1923

No. 1

When Is Siliceous Aggregate Objectionable?

WHAT kind of aggregates shall be used to make concrete most highly resistive to fire? What aggregates are under suspicion?

There is an increasing recognition of the hazards of siliceous aggregates for concrete which should have high fire resistance, yet there appears so far to be no satisfactory answer to the question: When is siliceous aggregate an additional hazard? In what form and in what quantity?

Some light is being thrown on this subject by the tests which are being run at the Underwriters' Laboratory, Chicago, by Committee P-5 on Fire Resistance of Concrete Building Units of the American Concrete Institute.

The blocks tested are made of various materials. Not all of the tests have been run, but so much of the work as has been done indicates that block made with an aggregate consisting of so-called calcareous gravel from Elgin, Ill., have shown a high degree of fire resistance; while tests on so-called siliceous gravel from Meramec river performed very badly. Analysis shows that the Elgin gravel contains from 30 to 40% of siliceous material, while the Meramec gravel ranks with Cowboy, N. Y., gravel as having the most silica of any in the country—93%. The question arises as to the point at which the percentage of silica in the gravel becomes a menace under severe fire tests! Calcareous gravel having 40% has shown good fire resistance. One question is: At what point between the 40% silica gravel and the 93% silica gravel is the safety line to be drawn? A number of gravels analyzed contained from 50% to 70% of silica, but these have not figured so far in the concrete block fire tests. It is a matter of considerable importance to the sand and gravel industry and to those who are using a large amount of gravel in making concrete to find out at what point the siliceous content of gravel becomes a serious factor in fire resistance of the concrete. This opens up possibilities for a large study of the fire resistance of various aggregates in concrete that are entirely beyond the program of Committee P-5 of the American Concrete Institute. Leslie H. Allen of the Portland Cement Association is chairman of this committee.

There is, however, a second question: Is it the amount of silica in the aggregate or its geologic form or combination which provides the guiding factor in choosing the right material?

The suggestion is offered from an authoritative

source that the silica in the Elgin gravel may be present as chert or flint and therefore not subject to the sudden explosive expansion that quartz undergoes at 573°C. It is not so much the percentage of silica as the amount and size of quartz grains (which must be distinguished from chert and other forms of silica). Very small grains of quartz may be so scattered that the strain caused by their sudden expansion will be taken up by shrinkage of clay or hydrous iron oxides or natural voids. Thus a fine grained quartz sandstone may withstand high temperatures very well, whereas a rock or gravel containing large grains or pebbles of quartz disintegrates. Gneiss containing only 25 or 30% of quartz in coarse grains (3 millimeters or more in diameter) are subject to such disintegration whereas fine grained granites containing just as much quartz are less subject to it.

It may be that some quartz contains an unusually large amount of fluidal or gaseous inclusions which vaporize and expand when heated and increase the tendency of quartz grains to "explode."

New England bank gravels may vary considerably in composition. Some consist largely of quartz and quartzite; others contain considerable granite and gneiss, and those near Boston may contain considerable flinty volcanic rock as well.

Owing to the different varieties of silica, it is suggested that the term "normal siliceous" gravel be abandoned, and that gravels be designated by their mineral composition. Thus a chert gravel should consist essentially of chert pebbles, a quartz gravel of quartz pebbles, and a quartzite gravel of quartzite pebbles. All may contain 95 to 100% of silica and all may behave differently from one another. Other siliceous gravels would include granite gravels, gneiss gravels, schist gravels, sandstone gravels, and mixed gravels, the last comprising various percentages of any of the above named rocks. Calcareous gravels should also be more precisely designated as dolomite gravels, limestone gravels, and cherty limestone gravels, as the dissociation temperatures of dolomite and calcite are sufficiently different to yield varying results in resistance to high temperatures.

Besides the principal constituents of gravels the minor constituents should also be stated in approximate percentages. It requires little time for a petrographer to determine the percentages of different rock and mineral pebbles present, and this determination is of fundamental importance, as the behavior of the gravels depends on the minerals (and rocks) present, and not necessarily on the chemical composition of the gravel as a whole.

Perhaps the Joint Committee on Concrete and Reinforced Concrete can give definite information which will guide the soon-to-be-distracted builder who wants to erect a concrete building of high fire-resistance.

FIG. 7—STANDARD 90-FT. GIRDER WITH 20-FT. ROADWAY

Standard Bridge Practice of the Michigan State Highway Department

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Read at Highway Engineering Conference, University of Michigan, Ann Arbor, February 15, 1922

The general design for a bridge structure is governed by four important conditions: The physical characteristics of the site, the requirements of traffic, the money available for construction, and the ideas of the owner or purchaser as regards type, ornamentation and special treatment. In a State such as ours, it does not then seem at all strange that when the entire list of structures on our public highways is scrutinized with the idea of reconstruction in mind, there should be a call for quite a varied list of types of structures to meet these conditions. Were time and means available, there would no doubt be as great a variety of types of structures as the conditions would warrant. Indeed, if the smaller political units directly controlling highway structures, were to handle the design of all of these structures, the types and variety of treatments adopted would far exceed the number for which there might be any legitimate need. On the other hand, whenever the responsibility for design of a large and varied group of structures is suddenly

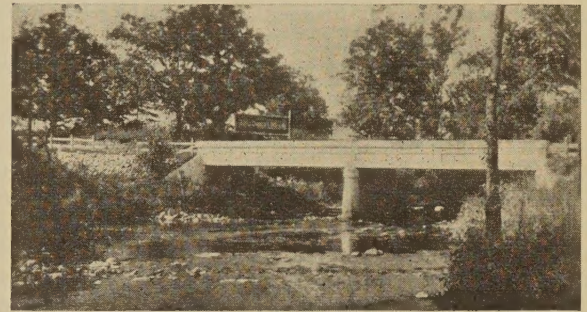


FIG. 2—SQUARE SPANS. TWO SPANS OF 45-FT. GIRDERS WITH 17-FT. ROADWAY

turned over to one organization to handle, the "economic necessity" arising from the provision of a small and undeveloped organization for handling of such a large problem will bring about the exercise of a great deal of ingenuity in the endeavor to reduce the number of types to a minimum and further, for each type, to provide designs which may, in their scope, take care of the greatest range of conditions. This soon leads to the provision of the so-called "standard plan" showing a general drawing with a key marking system referring to tables which enable the drawing of "standard plan" to be applied to quite a range of conditions.

The evil of such a standardized bridge lies in the temptation to use it for cases outside of the narrow limits to which the design applies and particularly to use it in cases where economy would dictate a radically different structure. From the standpoint of construction, it is also a hazardous matter not to have drawings to scale and when tables are used, many blunders have been made by reading dimensions or quantities from the wrong line in the table. The allograph or similar scheme for making multiple copies of tracings, with such figures and drawings as are characteristically common to the entire group and tables kept in the office, and from which dimensions, quantities, etc., are lettered directly on the allographs, is no doubt the most nearly ideal of such standard drawing, since this means furnishes all of the effect of a special drawing for each job, with the exception that it is out of scale. Common temptations arising from such standard plans are to build too narrow bridges, due to lack of standards for the particular width required; to build high abutments in plain concrete due to greater difficulty of standardizing reinforced abutments; to build wing abutments when stubs are not only economical but required by physical conditions; to omit sidewalks or provisions for same due to lack of standards; failure to provide for possibility of a wider roadway in the future; and the common case of building square spans where skews are both economical and essential. Whenever standardized

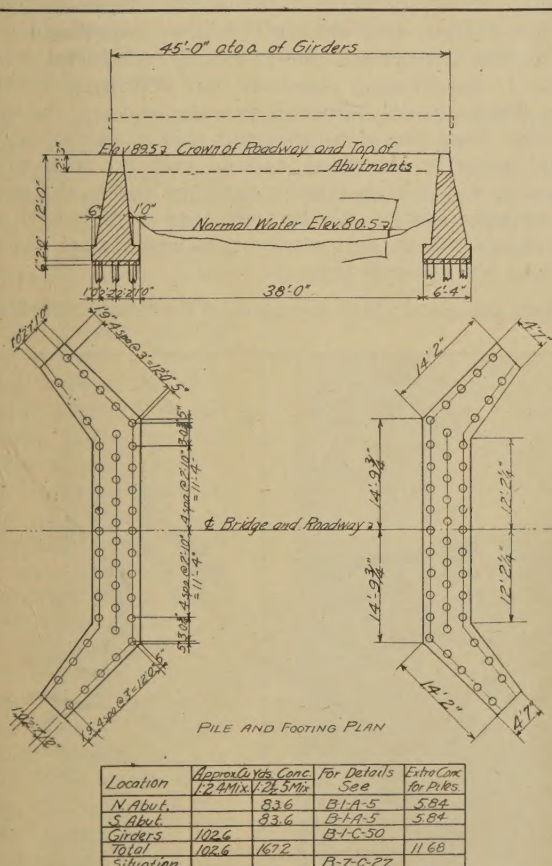


FIG. 1—TYPICAL SITUATION AND PILE PLAN, PILES REQUIRED IF ORDERED AFTER EXCAVATIONS ARE MADE

plans are used, it is highly essential that the very plainest of designs be used since the plans are intended for wide distribution to Township and County officials for the purpose of construction under local organizations. The Department found it highly important on all of its earlier standards to place on each drawing a perspective drawing which would show accurately and clearly both front and rear details, due to the inability of many users of the plans to properly read them.

Whether it is wise to thus provide for a large number of bridges at a saving of a little drafting room work in the face of the facts that such structures are uneconomical and are lacking in both beauty and a natural fitness for their location, is a matter of state-wide importance and one which is worthy of much consideration. There is a feeling that the State should exercise a greater control over bridges on our public highways which do not come under our Trunk Line or Reward system. There is at the present time a legal requirement, that the State shall furnish advice and plans in such cases if they are requested, but the State's investment in a bridge department is inadequate to any more than provide for its own needs on Trunk Line, Federal Aid and Reward bridges. Our bridge requirements have piled up on us for several years and it is all too often the case that the road is built before the bridge contract is let. The arteries of design become clogged quite easily because of the fact that with a small working force of some eight or nine men, just one special structure such as a movable bridge or a particularly complicated grade separation will tie up about half of the force for a whole season.

STANDARD ABUTMENTS

Standard abutments are drawn for a given height from bottom of footing to roadway and for a given roadway width and type of structure with provision for greater width by special tables showing changes for each foot change in width. It is evident that the length of the span to be carried, and whether span is concrete or steel, and the nature of the soil conditions require variable treatments and if suitable for long spans and soft foundations, there must of necessity be waste in both abutments and piling for shorter spans or for hard bottom or for light structures. Contractors are very liable to bid on quantities picked from the tables from the wrong column. Any abutment standard must assume a certain wing treatment. Most of these have assumed a 45° flare with a sloping wing cut off at a height at tip of wings of one-half the

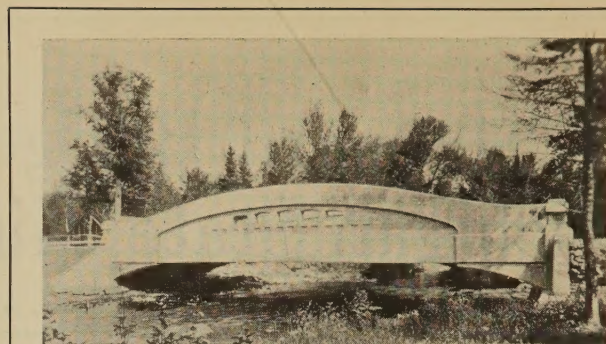


FIG. 4—VIEW OF 75-FT. CONCRETE GIRDER

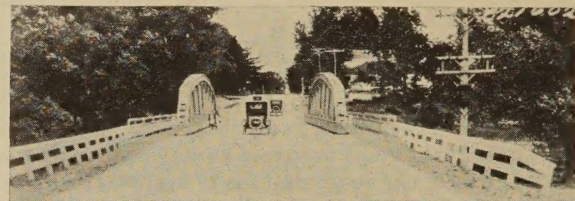


FIG. 5—STRUCTURAL STEEL BRIDGE

height from top of footing to crown of roadway, this type being chosen because, for a square span, it can be mathematically shown that it is most economical for the ordinary type of abutment with natural soil level and at a height but little above the top of footing. As a result, when the natural level of the ground is higher than the tip of these wings, the wing is buried, giving a very unsightly and unnecessarily expensive job. Field men have committed serious blunders due to the necessity of having to refer for each dimension from the drawings, which gives a key letter for a dimension, to the table which gives the value of the dimension under a given column and on a given line, sometimes with still further corrections due to caring for special conditions. It would seem essential that field men in these cases should have unlimited powers to vary the construction from the standards and this is an evil which should never be tolerated, as field men are seldom designers or noted for aesthetic qualities and as the terms of a contract are quickly brought into conflict with the field man's orders, and settlements and claims are the rule and not the exception.

When standard plans are used, it then becomes neces-

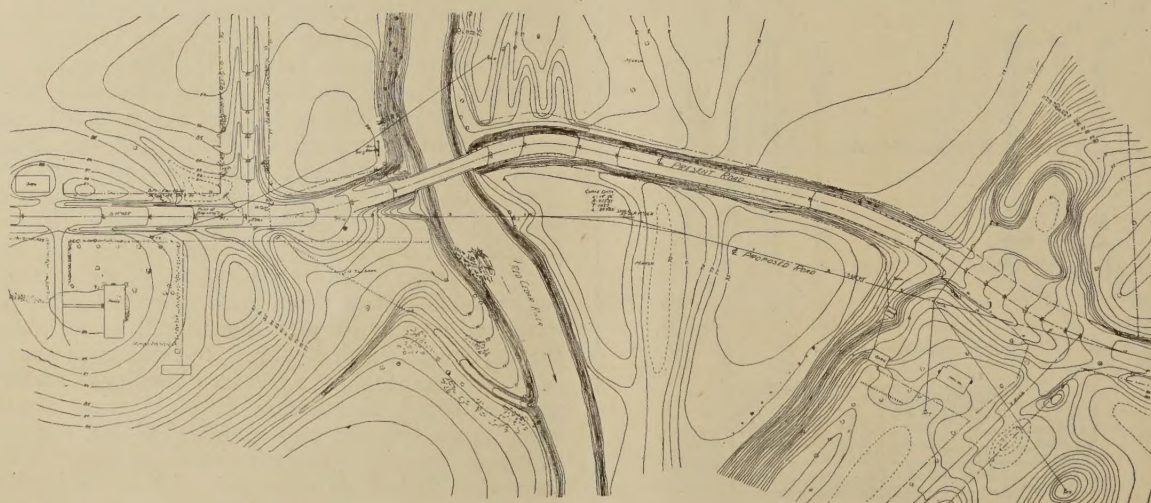


FIG. 3—LOCATION AND TOPOGRAPHY AT SITE OF BRIDGE

The Michigan State Highway Department has found that on bridge work, it is highly desirable that no bracing or form work above the top of curb shall be in place at the time of casting floor sections and finishing the roadway surfaces. We have therefore provided a multiple key arrangement in these girders at the top of curb level and place the construction plane at this level. This permits of not only securing the proper crown to the roadway, but also permits of striking the roadway surface on the camber outline for the girder and securing smooth and uniform surface that is, if anything, better than the surface secured on the pavement proper.

We are also modifying the crown of the floor surfaces on our bridges so as to correspond with our standard crown for concrete pavements. In placing our construction joints in these concrete girders at the top of curb, we have been guided by tests made with joints at such planes, these tests having been observed on three different structures having spans of 90 ft. We have loaded

these girders in the various tests with from 200 to 350 tons of superimposed load and have taken strain gage readings in the various parts of the girder as well as deflection readings to check up our stresses and the conservativeness of the design. Our tests have been more than satisfactory in confirming our methods of design as well as indicating a conservativeness in this respect.

We have plans for a 100-ft. concrete girder nearing completion and find that this structure can be economically used up to a limit of about 120 ft.—in fact is more economical at 120 ft. than at 100 ft.

We find that under the assumption of \$40.00 per cu. yd. of superstructure concrete in place, as against the price for structural steel at \$0.071½ erected, and with the field painting, and \$50.00 per cu. yd. for concrete floor, that at 100 ft. the comparison of cost is on an equal basis, while at 120 ft. the concrete girder is from 5% to 8% cheaper. Under the lowest prevailing prices for steel and concrete in the past two years, we have found our concrete girders fully as economical.

sary in preparing drawings for a structure to prepare merely a simple "Situation Plan" showing the general layout and a tabulation of the list of standard drawings applying and of the quantities required. Such a Situation Plan is well illustrated by Fig. 1 which represents the requirements for a 45-ft. concrete girder bridge with 20-ft. roadway and B-1-A-5 Standard abutments. It will be noted that the drawing is extremely simple, so much so that some State Highway Departments furnishing such plans to Townships and Counties, have the work done by girls without technical training and operating at low salaries. In my opinion, there is no place for such help in a department making real bridge plans.

The early designs for abutments were particularly objectionable as were also the standard piers for skew structures. This will be noted by referring to an example of the standard concrete girders in use in connection with these abutments. These girders were of such design that the sides of the girder were in one unbroken plane without pilasters, but with recessed rectangular panels and with a coping on the top. When used for skew bridges, the ends of the recessed panels would fall over the backwall and behind the backwall notch on one abutment and would fall out in front of the abutment on the other side. Similarly, over a pier one panel would hang outside the pier and the other would come directly over it. An idea of this may be obtained by examining Fig. 2, which shows two spans of 45-ft. girders with 17-ft. roadway (measured inside of curbs) carrying T. L. 16 over the

Red Cedar river near Williamston, in Ingham County. This is a square span, and while it does not illustrate the skew conditions noted, it is readily noted how the remarks apply. This shows the B-1-A-5 abutment and the Standard pier formerly in use, as well as the old standard girder. These girders were standard and to a large extent with slight variations are still standard in many states. In this state they became widely known as Dewart's tunnels due to their massive appearance and the fact that Dewart as Bridge Engineer for the State was responsible for giving them wide publicity here. The particular structure shown also furnishes a good example of the modern problem of what to do with a narrow bridge on poor location and only five years old, in the face of the demands for a wider and safer roadway for traffic of rapidly increasing volume. In this connection, it is to be noted that of a total of 366 structures put under contract to date, 148 or about 40.5% have been of 18-ft. roadway. Very few 18-ft. roadways are being built today. Fig. 3 shows the location and topography at the site of this bridge and it is

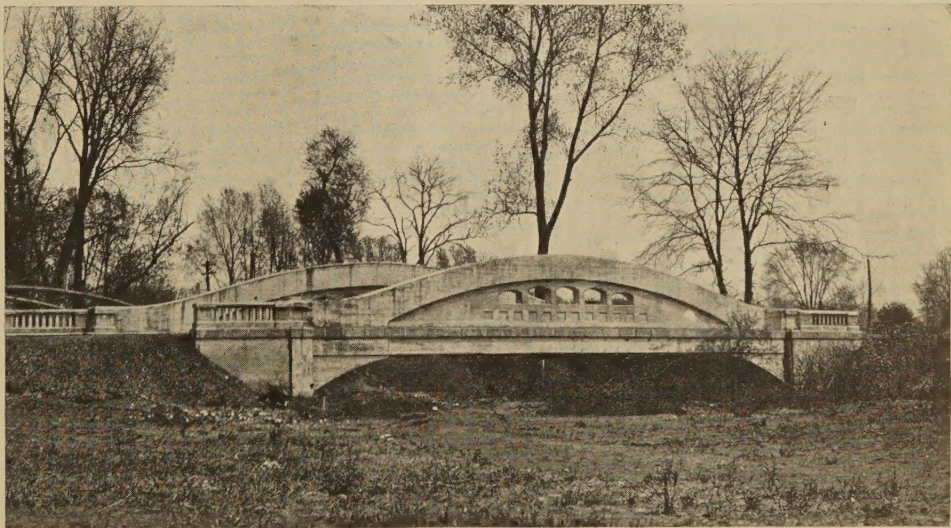


FIG. 6—A 90-Ft. GIRDER, WITH NO WALKS ON EITHER SIDE

easily seen that the temptation to scrap the old bridge is tremendous. Any public official responsible for building the old structure has to face the public charge of waste of funds on the one hand and of failure to provide adequately for present traffic on the other. Fortunately, most of the 17-ft. and 18-ft. roadways on structures were built from 1913 to 1916 at prices from $\frac{1}{3}$ to $\frac{1}{2}$ of the maximum prices of 1919 and 1920 and therefore the sting of the financial loss is considerably alleviated.

The question of leaving the place or destroying these old girders in case of an improvement and widening by relocation is one other problem under consideration. It has been proposed to cover some of these old structures with vines and shrubbery and develop them in connection with a sort of a roadside park and thus leave them in place.

STANDARDIZATION OF DESIGNS

This now leads up to a determination of just how far it is desirable and feasible to go in the matter of standardization of bridge designs. The factors governing the design of bridges may be classed as Fundamental Factors and Secondary Factors. The Fundamental Factors may be listed as—

1. The Clear Span; 2. Clear Roadway at Curbs and Hubs; 3. Height from Crown of Roadway to Bottom of Footings; 4. Angle of Crossing.

The Secondary Factors may be listed as: 1. Necessary Depth from Crown of Roadway to Bridge Seat; 2. Provisions for Maintaining Traffic; 3. Lighting Requirements; 4. Aesthetic Treatment required; 5. Street, Property and Protection Arrangements; 6. Limitations in Elevations due to High and Normal Water Level and Logging and Ice Conditions and Roadway Grade; 7. Necessity of Building Bridge on a Grade; 8. Provision for Public Utilities, Unusual Loading and Widths, etc.; 9. Accessibility of Materials and Transportation Conditions; 10. Height from Crown of Roadway to Natural Elevation of Banks; 11. Adequacy of Present Proposed Width of Structure; 12. Character of Foundations; 13. Wing Treatment for Protection or Economy.

If we were to suppose that we could neglect all secondary factors (and this is far from being the case), it can easily be seen that the probability of a combination of any given values of the four fundamental factors being required more than once is small indeed. In our practice we find that up to July 1, 1920, the Department had put under contract 240 bridges of which 131 were concrete girders (55%). Of the total bridges put under contract to this date, Feb. 1, 1923, viz. 366, it is found that 86 have been skew spans, or 23½%. On this basis, of the 131 bridges noted above, 100 would be square spans. It is found that of these 100 bridges, there were six 35-ft. girders, with 18-ft. roadway, 12-ft. abutment height, on a 90° crossing, three 15-ft. girders, 18-ft. roadway, 15-ft. abutment height, on a 90° crossing, or with only 3 factors considered, the plans might be used only from 3 to 6 times in 100 similar cases. If the number of factors be reduced to two, say span and roadway, thus covering superstructures, it is found as above that there were twenty-two 35-ft. girders, with 18-ft. roadway, eighteen 40-ft. girders with 18-ft. roadway, and fourteen 40-ft. girders with 20-ft. roadway. This would seem to indicate plainly that when the secondary factors are considered, the probabilities of duplication become much smaller and the economy of standardization becomes doubtful. Secondary factors affect design greatly. Thus a 90-ft. concrete girder must have 8-ft. depth from crown of roadway to bridge seat while a 50-ft. girder may take only 3 ft. 6 in. This calls, aside from loading, aesthetic treatment, etc., for an entirely different design of abutments. A steel superstructure requires radically different bridges seat and backwall arrangements and parapet wing treatment from a concrete girder job. Widening requirements demand the provision of long bridge seats and a wing treatment of their own and bar

the use of splayed wings. Property development up to the bridge requires the use of U wings at full height with either temporary or permanent railings thereon. Straight and high banks with full spans will call for stub abutments. When sidewalks are to be added in the future face walls must be long to take care of future slopes.

It is apparent from the above figures that it would be economical to standardize superstructures since, of the variables of span and roadway, there are comparatively few widths used and sidewalk requirements are comparatively few. We therefore have concluded that standardization must be restricted to the following:

1. Prepare Standard Superstructure Designs for Common Roadway Widths, (18-20-22-24), with and without walks and providing for future walks.

2. Prepare standardized methods for supplementing standard square span superstructures for skew conditions (for use of draftsmen only).

3. Prepare standard details of bridge seat and backwall treatment for the various standard cases (for use of draftsmen).

4. Prepare a record of all of the fundamental and secondary factors applying to each job drawn up, and cross index and use for purpose of combining and compiling similar jobs (for use of chief draftsman and bridge engineer). This list should also include quantities in various units of the job for estimating purposes and for studying the economy of the design with reference to the need for revising the plans at the first breathing spell. This permits the use of green men on fairly difficult jobs and conserves the designers' and checkers' time and promises the job in a minimum of time.

5. Standardization of certain details for use in the drafting room, such as design charts, railing spindles, pilaster and other details, backwall wings and bridge seats, pier noses, belt courses, molding, standard notes and titles, standards of drafting, standard arrangements and sizes of drawings, guard rail and fill shoulder, relations to structures and fills around wings, standard panels, methods of design, standard clearances, floor details, and tabulation of properties of design frequently used.

TYPE OF STRUCTURE

Before preparing standard superstructure designs, it first becomes necessary to decide on the type or types of superstructure which are to be adopted. Aesthetically, the public eye demands an arch. However, an arch is most peculiarly unsusceptible of standardization. It requires hard pan or rock bottom and a full knowledge of this fact beforehand, and also a full knowledge of the lay of the ledge. The span is inseparably linked with the height and thus decreases to a small percentage the probability of re-use of the span. The type of abutment is inseparably linked with the height and span and rise. In addition to the lack of economy of standardization, the time necessary for arch analysis and details is about twice to three times that for any other special plan and the probability of widening such a span economically is far inferior to a girder design. In addition to all of the above unfavorable points, is the fact that the greater portion of our Michigan bridges require piling, and further require more waterway than can be secured for equal spans of arches as compared with girders, and, further, our valleys are too low and flat to furnish sufficient rise for arch spans without resorting to very flat rise ratios. It would seem then that the arch should be considered for special occasions where it may prove appropriate and desirable. Prior to July, 1920, the Department's construction list shows 13% of its 240 bridges as arches, but of this 13% many were built on piles on extremely poor bottom and but few of them on foundations which come under the hardpan or rock classification, showing the effect of the public clamor for the "Arch Beautiful."

Having eliminated the arch as our standard superstructure, we should next turn to the most economical of all structures, the deck superstructure. It will take but a moment's consideration to eliminate this type from the field, for Michigan valleys are too flat and its stream level variations too great to permit

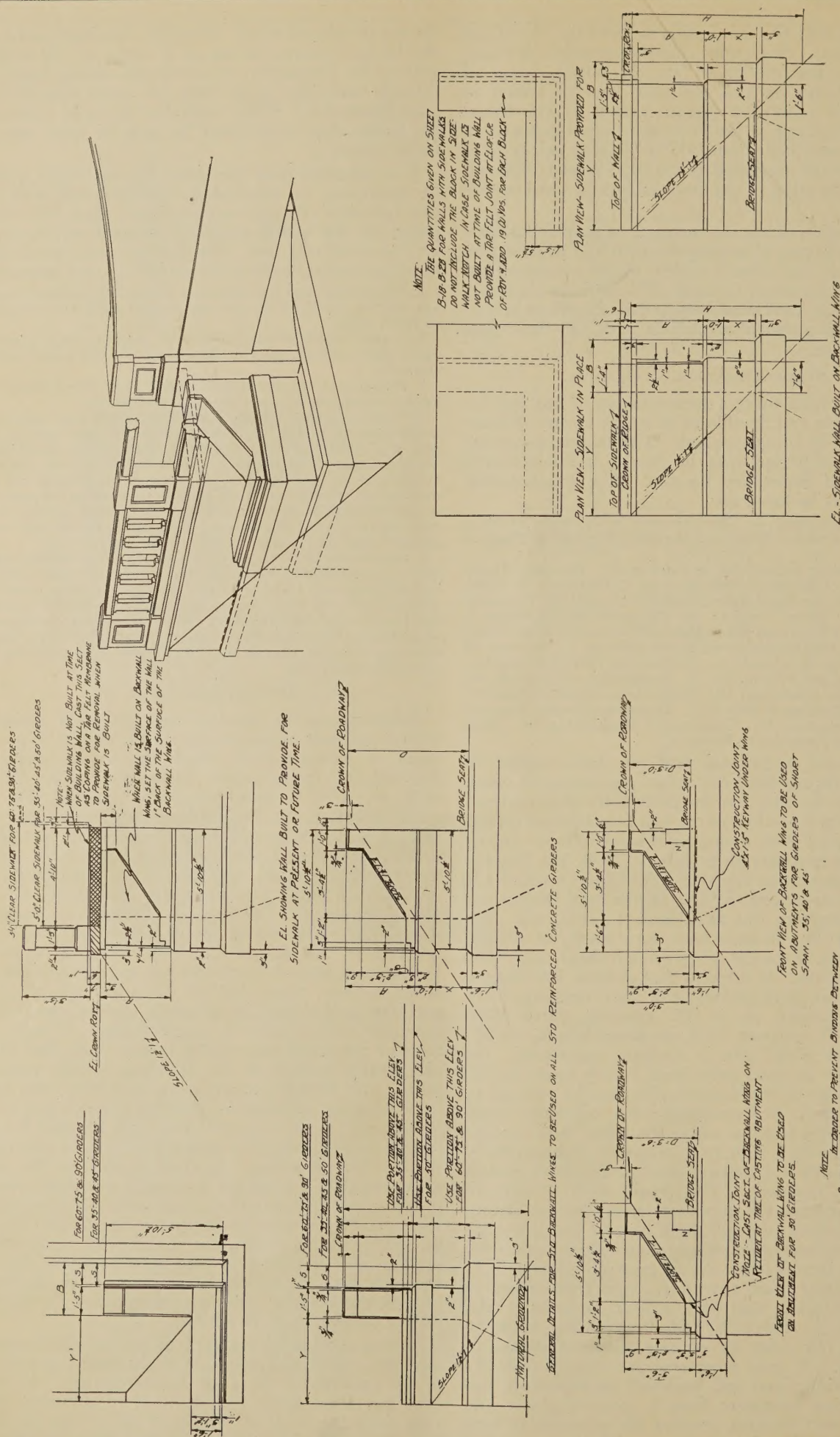


FIG. 9—STANDARDS FOR BACK WALL WINGS

DATA ON STANDARD GIRDERS TO BE USED IN THE DESIGN OF ABUTMENTS AND STANDARD BACKWALL WINGS

Span	Roadway	Sidewalks	Clearance	Cu. Yds. Conc.	O to O of Pilasters	Length of Abut.	D	B	S	X	Z	A	Min. H	Yds. Conc. Y = 0*	Y	Conc. Per Ft. of Y*	G. Steel	Steel/Sq. Ft. Floor	Conc./Sq. Ft. Floor	File No.
35'-0"	18'-0"	Without Provision for With 5'-0"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
"	"	"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
"	20'-0"	Without Provision for With 5'-0"					3'-0"	1'-11"	0'-6"			3'-0"	4'-6"	.975	1.5H-1'-11"	.186				
"	"	"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
"	"	"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
"	22'-0"	Without Provision for With 5'-0"	1'-9"		27'-6"	39'-3"	3'-0"	1'-11"	0'-6"		2'-4"		4'-6"	.356	(H-4'-6") 1.5-1'-11"		11540 lbs.	15.0 lbs.		A-4-C-13
"	"	"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
"	24'-0"	Without Provision for With 5'-0"	2'10"	64.9	29'-0"	40'-9"	3'-0"	1'-11"	0'-6"		1'-7"		4'-6"	.975	1.5H-1'-11"	.186				
"	"	"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"		14700 lbs.	17.5 lbs.	0.077 cu. yds.	A-4-C-30
"	"	"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
40'-0"	18'-0"	Without					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
"	"	Provision for With 5'-0"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
"	20'-0"	Without Provision for With 5'-0"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
"	"	"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
"	22'-0"	Without Provision for With 5'-0"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
"	"	"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
"	24'-0"	Without Provision for With 5'-0"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
45'-0"	18'-0"	Without	3'-0"		23'-6"	35'-3"	3'-0"	1'-11"	0'-6"		1'-7"		4'-6"	.975	1.5H-1'-11"	.186				
"	"	Provision for With 5'-0"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
"	20'-0"	Without Provision for With 5'-0"	3'-0"		23'-8"	35'-5"	3'-0"	1'-11"	0'-6"		1'-7"		4'-6"	.975	1.5H-1'-11"	.186				
"	"	"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
"	"	"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
"	22'-0"	Without Provision for With 5'-0"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
"	"	"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
"	24'-0"	Without Provision for With 5'-0"					3'-0"	1'-11"	0'-6"				4'-6"	.356	(H-4'-6") 1.5-1'-11"					
50'-0"	18'-0"	Without					3'-0"	1'-11"	0'-6"				4'-6"	.975	1.5H-1'-11"	.186				
"	"	Provision for With 5'-0"					3'-6"	1'-11"	0'-6"				5'-0"	.505	(H-4'-6") 1.5-1'-11"	.024				
"	20'-0"	Without Provision for With 5'-0"	2'-0"	100.0	26'-0"	37'-9"	3'-6"	1'-11"	0'-6"				5'-0"	1.120	1.5H-1'-11"	.211				
"	"	"					3'-6"	1'-11"	0'-6"				5'-0"	.505	(H-4'-6") 1.5-1'-11"	.024	21790 lbs.	21.8 lbs.	0.100 cu. yds.	A-4-C-3
"	"	"					3'-6"	1'-11"	0'-6"				5'-0"	.505	(H-4'-6") 1.5-1'-11"	.024				
"	22'-0"	Without Provision for With 5'-0"	2'-0"	116.7	28'-4"	40'-1"	3'-6"	1'-11"	0'-6"		1'-6"		5'-0"	1.120	1.5H-1'-11"	.211				
"	"	"					3'-6"	1'-11"	0'-6"				5'-0"	.505	(H-4'-6") 1.5-1'-11"	.024	25930 lbs.	23.6 lbs.	0.106 cu. yds.	A-4-C-15
"	"	"					3'-6"	1'-11"	0'-6"				5'-0"	.505	(H-4'-6") 1.5-1'-11"	.024	29840 lbs.	27.1 lbs.		A-4-C-17
"	24'-0"	Without Provision for With 5'-0"	3'-6"	130.4	31'-4"	43'-1"	3'-6"	1'-11"	0'-6"		1'-8"		5'-0"	1.120	1.5H-1'-11"	.211				
"	"	"					3'-6"	1'-11"	0'-6"				5'-0"	.505	(H-4'-6") 1.5-1'-11"	.024	27315 lbs.	22.8 lbs.	0.109 cu. yds.	A-4-C-29
60'-0"	18'-0"	Without					5'-6"	1'-11"	0'-6"				7'-0"	1.205	(H-4'-6") 1.5-2'-7"	.146				
"	"	Provision for With 5'-0"					5'-6"	2'-7"	1'-1"	1'-0"			7'-0"	1.205	(H-4'-6") 1.5-2'-7"	.146				
"	20'-0"	Without Provision for With 5'-0"	2'-6"	137.0	26'-8"	38'-5"	5'-6"	2'-7"	1'-1"	1'-0"			7'-0"	1.205	(H-4'-6") 1.5-2'-7"	.146				
"	"	"					5'-6"	2'-7"	1'-1"	1'-0"			7'-0"	1.205	(H-4'-6") 1.5-2'-7"	.146				
"	"	"					5'-6"	2'-7"	1'-1"	1'-0"			7'-0"	1.205	(H-4'-6") 1.5-2'-7"	.146				
"	22'-0"	Without Provision for With 5'-0"					5'-6"	2'-7"	1'-1"	1'-0"			7'-0"	1.205	(H-4'-6") 1.5-2'-7"	.146				
"	"	"					5'-6"	2'-7"	1'-1"	1'-0"			7'-0"	1.205	(H-4'-6") 1.5-2'-7"	.146				
"	24'-0"	Without Provision for With 5'-0"					5'-6"	2'-7"	1'-1"	1'-0"			7'-0"	1.205	(H-4'-6") 1.5-2'-7"	.146				
75'-0"	18'-0"	Without	3'-0"	190.3	25'-0"	36'-9"	6'-0"	2'-7"	1'-1"	1'-6"			7'-6"	1.367	(H-4'-6") 1.5-2'-7"	.173	39008 lbs.	28.9 lbs.	0.141 cu. yds.	A-4-C-33
"	"	Provision for With 5'-0"					6'-0"	2'-7"	1'-1"	1'-6"			7'-6"	1.367	(H-4'-6") 1.5-2'-7"	.173				
"	20'-0"	Without Provision for With 5'-0"	3'-0"	197.7	27'-0"	38'-9"	6'-0"	2'-7"	1'-1"	1'-6"			7'-6"	1.367	(H-4'-6") 1.5-2'-7"	.173				
"	"	"					6'-0"	2'-7"	1'-1"	1'-6"			7'-6"	1.367	(H-4'-6") 1.5-2'-7"	.173	42076 lbs.	28.1 lbs.	0.132 cu. yds.	A-4-C-20
"	"	"					6'-0"	2'-7"	1'-1"	1'-6"			7'-6"	1.367	(H-4'-6") 1.5-2'-7"	.173				
"	22'-0"	Without Provision for With 5'-0"	3'-0"	198.0	29'-8"	41'-5"	6'-0"	2'-7"	1'-1"	1'-6"			7'-6"	1.367	(H-4'-6") 1.5-2'-7"	.173				
"	"	"					6'-0"	2'-7"	1'-1"	1'-6"			7'-6"	1.367	(H-4'-6") 1.5-2'-7"	.173	55030 lbs.	33.4 lbs.	0.120 cu. yds.	A-4-C-8
"	24'-0"	Without Provision for With 5'-0"					6'-0"	2'-7"	1'-1"	1'-6"			7'-6"	1.367	(H-4'-6") 1.5-2'-7"	.173				
90'-0"	18'-0"	Without					8'-0"	2'-7"	1'-1"	3'-6"			9'-6"	2.020	(H-4'-6") 1.5-2'-7"	.285				
"	"	Provision for With 5'-0"					8'-0"	2'-7"	1'-1"	3'-6"			9'-6"	2.020	(H-4'-6") 1.5-2'-7"	.285				
"	20'-0"	Without Provision for With 5'-0"	3'-0"	255.0	27'-0"	38'-9"	8'-0"	2'-7"	1'-1"	3'-6"			9'-6"	2.020	(H-4'-6") 1.5-2'-7"	.285				
"	"	"					8'-0"	2'-7"	1'-1"	3'-6"			9'-6"	2.020	(H-4'-6") 1.5-2'-7"	.285	61500 lbs.	34.2 lbs.	0.142 cu. yds.	A-4-C-25
"	"	"					8'-0"	2'-7"	1'-1"	3'-6"			9'-6"	2.020	(H-4'-6") 1.5-2'-7"	.285				
"	22'-0"	Without Provision for With 5'-0"	3'-0"	247.6	29'-0"	40'-9"	8'-0"	2'-7"	1'-1"	3'-6"			9'-6"	2.020	(H-4'-6") 1.5-2'-7"	.285				
"	"	"					8'-0"	2'-7"	1'-1"	3'-6"			9'-6"	2.020	(H-4'-6") 1.5-2'-7"	.285	69600 lbs.	35.2 lbs.	0.125 cu. yds.	A-4-C-10
"	24'-0"	Without Provision for With 5'-0"	3'-0"	269.5	31'-6"	43'-3"	8'-0"	2'-7"	1'-1"	3'-6"			9'-6"	2.020	(H-4'-6") 1.5-2'-7"	.285				
"	"	"					8'-0"	2'-7"	1'-1"	3'-6"			9'-6"	2.020	(H-4'-6") 1.5-2'-7"	.285	72747 lbs.	33.7 lbs.	0.125 cu. yds.	A-4-C-31

*Quantities in this column are for 1 Backwall Wing.

depths under the roadway to underclearance in excess of three feet. This would apply to fully 90% of all our structures. In fact, road requirements usually have to be greatly sacrificed in order to comply with this limitation of three feet and many cases arise when 24-ft. roadway requirements have to be sacrificed in favor of 22-ft. to permit the use of slab floors with consequent shallow depths to under clearances. To this date, the department has built but one deck concrete girder

bridge and but a few deck steel structures, much less than 5% of our program. Logging operations and ice jams form a still further ban on the deck type of structure. It is felt that our longer concrete girders now in common use furnish all of the advantages of cheap substructures in addition to their other numerous advantages.

This brings us to the consideration of steel superstructures such as girders and trusses as against con-

crete structures of a through type. We will first consider the steel structure from the standpoint of the serious objections to its use for highway bridges in general and note what we consider its proper place in the highway field.

1. No one will question the superior beauty of one of our 75-ft. concrete girders (Fig. 4) as compared with one of our new steel low truss bridges (Fig. 5), although here we see steel at its best, from an aesthetic consideration.

2. A steel structure must be artificially protected from the weather and this protection is short lived, not ordinarily over five years, and at the best, the parts which need protection of the best, are generally inaccessible for painting and therefore receive no paint. The structure is doomed to be placed in the "Semi-permanent Class," that is, it is not likely to last over 35 years with the type of maintenance commonly received.

3. To properly protect such a structure costs around 3% of its original cost each year, and this figure does not include any depreciation or sinking fund allowance.

4. Up to 100-ft. spans, as will be shown later on, steel superstructures with concrete floors have a greater first cost than concrete girders designed for equal capacities.

5. Neglect of maintenance is a dangerous thing and while the present organization may be efficient in this line, there is no guarantee on the future; and in addition, maintenance organizations are not always of the high class that we sometimes hope they are. Maintenance neglect is, then, a serious reflection on the policy of using steel superstructures.

6. There is usually no meaner job to inspect for maintenance needs than a steel structure. Water and wind carry the earthy elements to the most remote places and the earthy elements hold the moisture in contact with air and steel for almost permanent periods. Concrete itself adjacent to steel is peculiarly an unfavorable element in the life of the steel if air should have access to the common line of contact and particularly so if lime be present in the concrete. Furthermore, it becomes frequently impossible to clean the surfaces in contact and at which the corrosion is most severe. The inconvenience of inspection becomes, then, a serious criticism of such a design.

7. When a paint crew comes along they fail to clean the structure properly and paint over damp, dirty, greasy or rusty places, and make inspection more difficult and lend a false feeling of security in the structure's safety—and shortly the paint peels off and the places needing protection worst are not protected to any extent worthy of the name. Thus, the practical inability to properly maintain the structure is also a serious objection.

8. Expansion details on a steel bridge are difficult to provide satisfactorily, inasmuch as expansion planes at two levels must usually be provided for at one end of the structure. That is, when stringers rest on the backwall and are also connected to an end floor beam and the trusses slide on roller nests on the bridge seat, the latter elevation is fixed for concrete and steel and at the stringer rests it is impossible to get a sliding contact in harmony with the shoe expansion, the result being a severe strain in the floor slab, stringers and floor beams, with resultant cracking of the floor slab or loosening of rivets in connections. The department has recently worked out a detail free of these criticisms, but it is still far from being as desirable as is secured for a concrete structure.

9. There are but few fabricating companies which are turning out highway bridge work in accord with

specification requirements. The greatest criticisms apply to field connections, alignments and fits. These are critical connections and the concrete girder has the advantage over steel in that the workmanship is uniform throughout, whereas for the steel the work is no better than the field connections, regardless of excess strength due to well-made members.

10. It is almost impossible to get a good job of erection, regardless of the excellence of shop work. Very few fabricating companies of good reputation do their own erecting. They are very careless in subletting this work and so here again, since the structure is no stronger than its connections, we get an inferior job regardless of perfect fabrication. It takes a good sized job in easily accessible location to tempt a good fabricating company to erect, and the average highway bridge is small in tonnage, usually on a road remote from town, unimproved, or on a road where a fresh grade has just been laid, and far from a railroad station.

11. Whenever a steel job is let, no assurance can be given that the substructure will be ready in time and delays in mill shipments, railroad transportation difficulties for lack of cars, strikes, etc., and fabrication troubles all greatly increase the difficulty of setting a date for letting a contract for the concrete floor. No bridge contractor cares to build the substructure and then tie up his equipment for a small floor job which may not be ready for some six months. The delays incident to three contractors frequently mean carrying the investment over winter without use by the public, because of the impracticability of protecting a concrete floor job in the winter time. Often it is found desirable to place a plank floor temporarily in the winter time, but this only further adds to the cost of the structure. In the case of a concrete superstructure, the substructure contractor is fully capable of building the superstructure and there would be no delays due to waiting for materials, fabrication or shipping, or to other parties are involved. The one contractor sets the date for the entire job and there is no divided responsibility for completion, maintenance of traffic, responsibility for poor workmanship or finish, or getting in the way of the other man's job. There are more good concrete contractors than there are fabricating and erecting contractors.

The above discussion conclusively indicates that the type of superstructure which must be chosen for standardization is the Through Concrete Girder and that aside from standards for such superstructures, we should prepare standard details and methods as previously outlined.

It has long been the general practice in this country to use a proportion of 1:2:4 for reinforced concrete structures, but it is apparent that if we are to make concrete girders the backbone of our design, we must secure the greatest strength possible and as small a dead load in proportion to the carrying capacity as is consistent with such strength. We have therefore increased our mix to 1:1½:3, increasing our allowable unit stresses 25%, with an increase of only 0.4 bbls. of cement per cu. yd. of concrete or, say, 90c per cu. yd. Since our average price for concrete in place in these structures is about \$32 per cu. yd., at this time, this 25% increase in strength is obtained at a cost increase of not more than 2.8%, and when the workability and ease of finish are considered the cost increase is certainly not over 2.5%. This would be still further decreased by the fact that the decrease in quantities required would decrease our dead load stresses.

What Properties and Methods of Making Concrete Require Further Investigation?

A symposium: "What properties of and methods of making concrete require further investigation?" was included in the thirteenth session of the twenty-sixth annual meeting of the American Society for Testing Materials at Atlantic City on June 29. The requirements of concrete to meet the many varieties of service conditions were discussed with the object in view of determining what can be learned from behavior of actual structures. The purpose of the symposium was to bring to the attention of engineers, the need for further intensive study of concrete as a material.

The introduction by Frank C. Wight, managing editor *Engineering News-Record*, classed the symposium as a stock-taking discussion and an attempt to get away from the view of concrete as a combination of cement, sand, stone and water which possesses certain physical properties to be studied, and to look at it in a detached fashion as a material to perform a service.

It is more important that the record of the actual structural behavior be studied in concrete than in any other material. Concrete is a chemical combination subject to all the variations in structure that that implies.

Changes in placed concrete are contrasted with those in Venetian glass where perfection or lack of perfection is assured when it cools in the mold. With concrete only the defects of those grades classed as 60% or less perfect may be discovered when the forms are removed. One of the aims of the discussion is to go back 10 or 15 years and to attempt to discover from the behavior of existing structures of that or greater age what were the properties and methods of making, that affected their present known condition, whether it be good or bad.

The scheme of the discussion as outlined in the introduction was first to consider the constituents of concrete and its methods of making, in the light of the service requirements, to discover if possible, wherein lie future possibilities in cement, aggregates and proportioning and mixing. This is to be followed by a study of service conditions in roads, in sea water, in alkali water, and under the normal attacks of weather tying up the behavior insofar as possible to the kind of concrete actually placed.

Cement

By P. H. BATES

CHEMIST, U. S. BUREAU OF STANDARDS, WASHINGTON, D. C.

Published by permission of the Director of the U. S. Bureau of Standards. Presented at the Twenty-Sixth Annual Meeting of the American Society for Testing Materials at Atlantic City, N. J., June 25 to 29, 1923.

As a text or a thought around which to write this partial contribution to the general topic of today, we might change the general title by substituting the word "cement" for "concrete" and have "What Properties of and Methods of Making Cement Require Further Investigation?" Our experience has been such that we are not well equipped to discuss the second part of this title, but it forms such an important part that at least some thoughts must be expressed in this connection. To discuss needed physical properties without taking into consideration how these would affect present methods of production or to omit a discussion of the investigations needed in production methods would be possibly leaving the most important part of the subject untouched.

Portland cement must have certain properties to meet certain service conditions. These latter have been well condensed in the program of this meeting into six broad services or conditions of use, namely, roads, sea water, alkali, atmospheric, mass concrete and reinforced concrete. For the purpose of discussing the required properties of cement, we are going to further condense these to three conditions under which resulting cement products will be used: namely,

Class I.—Those atmospheric conditions in which the product will not be subjected to actual contact with water after making, but be subjected to only the water vapor present in the air. In this class of products we have reinforced concrete buildings and mortars used on the interior of structures, especially as the top coat of floors.

Class II.—Those conditions in which the product is subjected continuously or intermittently to contact with water of a fair purity or low in solids composed largely of sulfates. In this class we find the greater use of cement, for it comprises such uses as in roads, mass concrete, stuccos, sewers, drain tile, etc.

Class III.—Those conditions in which the product is subjected to the action of a solution of salts, especially sulfates. In this class appear concrete used in sea water and concrete used in those arid regions where the soils contain considerable amounts of sulfate salts, as our "white alkali" regions of the West.

There are of course certain cases where we might consider overlapping in these classes, as, for instance, the roads in our dry southwestern country where there is little or no precipitation of water and where the humidity is far less than in the northern and eastern part of the country; or the concrete in certain sewers where the salt concentration may be so high that we would have to consider it as being subject to salt action. But in general these three classes represent the major conditions in which cement products are used and for which the cement should have such properties as would enable it to give adequate, if not permanent, service.

Before becoming too much involved in this discussion, it were better to elaborate upon what we should expect of cement in its various products—adequate or permanent service. Are we not fundamentally wrong in saying or hoping that cement products should be even approximately permanent? We are, of course, inclined to make those odious comparisons with structures of previous civilizations around the Mediterranean Sea and to refer to them as having withstood the ravages of the ages and to our structures as being on a rapid road to destruction. Then we have the frequent comparison of cement products with stone, the latter being considered the acme of permanence in our climate. But these comparisons are most unfortunate. Let us move away from that most salubrious climate existing around the Mediterranean or the continuation of that

belt directly easterly or westerly around the world, and examine a few old structures and what do we find? We will just cite one or two instances from a note in *Science* recently:¹

"Every geologist from his own observations and reading can give many examples of rapid weathering, such as that on the western front of the Amiens Cathedral, probably not an original stone placed there by the builders in the fifteenth century can be found;² that the outside stones of Westminster Abbey have been renewed five times over; that the stone of which the British Houses of Parliament are built has crumbled so rapidly that already it has been necessary to replace many of the stone ornaments with cast iron. On the other hand, so many objects showing almost no evidence of weathering have been taken from tombs in Egypt where they were buried for many centuries, that little surprise was evinced when the Metropolitan Museum Expedition of 1919-20³ announced the discovery at Thebes, in the chamber of the tomb of a man of great wealth, of a large number of remarkably preserved small wooden models

... 'practically as perfect as the day they were made' ... but so little have they been affected by the agents of the weather that even the finger and thumb prints of the men who carried the figures up to the tomb are preserved. ... In the cavern of Tuc D'Audoubert ... in the Pyrennes, is an even more remarkable example of the lack of disintegration. In this case are the clay models of bison which are in nearly as perfect condition as when made. ... These models of bison are in fact slightly cracked but with this exception are unchanged. It is possible that the cracks were formed within the first few weeks after the figures were modeled and that none have developed in the 18,000 to 30,000 years that have followed. ... The conditions under which the art of paleolithic man has been preserved almost unchanged for thousands of years are to be found in uniform temperature, lack of sunlight and absence of circulating ground water. ... It is probable, however, that the moisture content of the air has remained constant and that because of this, the clay models have not disintegrated. The remarkable preservation of the Egyptian models of wood ... is due to uniform temperature, lack of sunlight and absence of moisture."

We see immediately from these typical cases that stone is not permanent, although any geologist would have told us that our kaolins are disintegrated granites and would have referred us to water in certain places as being very "hard" because of the dissolved limestone which it may contain. We also see that uniformity in atmospheric conditions is the greatest aid to permanency of all products—even modeling clay and wood—and that belt extending around the earth's surface and of which the Mediterranean is a part is one of few atmospheric changes. Hence, let us acknowledge that in cement and its products we are only properly concerned with a relatively permanent material and "relatively" may mean anything from a few years, or even months, to a hundred or more years depending upon the service condition. But in all cases we are concerned in a material which will give such adequate service, be it months or years, as coupled with its cost of installation and superiority of resulting product will justify its use.

CLASS I.—CONDITION OF EXPOSURE

The uses indicated in our Class I may seem to be the least severe of those to which cement may be placed. But even if such is the case, it is quite evident that we are in need of much research before we have the ideal cement for such purposes. It is well known that if we exceed a certain water-cement ratio we have a distinct falling off in strength and a decided increase in the amount of shrinkage which takes place during the early aging of any cement product. But it is just as well known that the optimum ratio must be exceeded if we are to take advantage of that flexibility in the use of cement under those conditions which have been the main features in its rapid advance in the structural industry. Otherwise we cannot economically place the concrete in large structures or in the complicated forms or properly around the reinforcing. We must make a

compromise therefore which entails the use of more water than we should use and consequently in certain ways—strength and shrinkage—obtain an inferior product, although in other ways it is superior. But what has been done, so far as the cement is concerned, to develop a cement which would possess a minimum strength reduction and a minimum increase in shrinkage with the use of increased amounts of water? We have not made any thorough or even preliminary investigation to see how the different brands of cement vary in these respects. It has been rather a marked fault with investigators, in concrete in particular, to use a blend of several cements and to obtain, consequently, average results. It is now time to investigate the quality of brands exhaustively, not only along those lines which would indicate their serviceability under Class I conditions but along any lines which would show the characteristic of different types of cement. This would form but a preliminary step in a research tending toward developing a cement affected in the least by the use of large quantities of water.

Very closely connected with the question of excess water used to produce readily flowing concrete is that of a more "workable" one obtained without the use of water in excess or admixtures of any kind. The need of a cement capable of producing "fat" mortars or readily "working" concrete has been the reason for the existence of a number of materials to be used as admixtures to concrete to produce this quality. The existence of these materials has furthermore been the reason for a number of series of researches tending to prove or disprove the conferring of these qualities. But how many researches have we in which it has been attempted to find if we have any cements more strikingly "plastic" than the others? Indeed, we have no method of determining this quality even relatively, yet when used as a bond in mortars, this quality is far more paramount than strength. With possibly one exception, there are no mortar bonding agents sold in competition with portland cement on a strength basis, but they are always sold and used on the basis of being more readily workable.

When cements are used in the top coats of floors, we come into a field where there has been more adverse criticism of it and possibly more "patent medicines" evolved to correct its defects in this respect, than in all other fields excepting possibly that where it is supposed to be impermeable to water. All floor finishers will say that with all cements there are occasions when a non-dusting, non-cracking floor is obtained and that with certain brands the likelihood of obtaining a good floor is far greater than with others. But they are seldom sure when the desired result will be obtained, and no one has developed a test or tests that will predict this quality. A research that would show just what constituent or combination of constituents in the cement, or what phenomena in the reaction of water on these, or what physical properties of the cement, as hardness of particles or fineness of grain, produce the expected and hoped-for result, would not only enable cement to regain a favor that it has lost in this use but would also reduce the cost of floors and materially increase the use of portland cement for such purposes.

It is believed also that this same research would solve the problem confronting road builders where or when a very low atmospheric humidity exists. A number of instances of trouble have been reported of roads cracking under these conditions before final set has been obtained—and the trouble has not been due to excess water of poor choice of aggregate or poor grading of aggregate. *The difficulty has been with the cement.* Here again our tests are at fault. We store all test pieces of cement under close to saturated humid-

¹Hudman F. Cleland, "Weathering under Constant Conditions," *Science*, Vol. LVI, 1458, p. 660 (December 8, 1922).

²J. W. Gregory, "Geology of Today," p. 91.

³*Bulletin*, Metropolitan Museum of Art, Vol. XV, December 1920, pp. 12-40.

ity conditions before and during the time of set. But much cement has to set in an atmosphere under considerably less than 50 per cent relative humidity and cannot be protected from evaporation during this period. If you are not familiar with what will frequently happen under such conditions, make duplicate pats from time to time and store them under low humidity as well as saturated humidity conditions. It will be surprising to note how often those specimens proving satisfactory under standard conditions of testing fail completely in the dry atmosphere. Also then remember that the cement must set in the dry atmosphere. Almost unquestionably the same set of phenomena that causes this cracking of roads before setting in dry atmospheres brings about the dusting and checking of floors.

Before leaving this class of uses we should like to call attention to the need of the study of volume changes in concrete when subjected to the atmospheric conditions defining this class. It has been our duty to examine the veneering of a large number of steel and concrete frame structures and we have been surprised at the relatively larger numbers of failures of the veneer on the concrete than on the steel structures. Architectural terra cotta, stone, and brick veneer show failures of a type that lead almost conclusively to the deduction that the concrete by contracting has induced strains in the veneer that have crushed it, especially when setting of the latter has been faulty due to the lack of fully embedding the individual units in the mortar. There has resulted from this combination of contracting and faulty setting a concentrated loading, especially on the edge of the units where pointing has been carefully done, which is manifested by a spalling at the edges. What causes this contraction—the aggregate, the cement or the water? The majority answers, the water. But excess water must be used for proper placement of the concrete. Hence, are we not back to the development of a cement or the adding of something to a cement after making, which will enable it to hydrate more fully in a given short time and retain this excess water? Furthermore, this water of hydration must be held so tenaciously that it will not be lost by desiccation under the usual atmospheric conditions. Our present "soundness" tests are supposed to determine "constancy of volume," but this is only very relative and not near to the degree of accuracy that we must have and will ultimately have for certain types of work.

CLASS II.—CONDITION OF EXPOSURE

In our Class II are embraced those uses of concrete into which the majority of cement ultimately finds its way. It is here also that cement has been eminently successful, but no one will question the value and need of research in still further improving it to meet the conditions of service existing here, for they are in many cases very exacting. A road saturated with water may freeze and in this condition be subjected to the action of a warm sun on one side while the other remains well below freezing. Or consider the condition of a sewer subjected to the action of water at practically all times and yet somewhat more than 50 per cent of the cement is soluble in water. A thoroughly dry stucco may suddenly be subjected to a heavy or long rain and while saturated be frozen. Such conditions as these are extremely severe, and if there were not universal success there should be no cause for wonder.

But note that the conditions here are somewhat different from those existing in the first class. In the latter the concrete is subjected to continued desiccation. Here it is subjected to either the continued influence of water or alternate periods of wetting and desiccation. It is assuming rather much to infer that a cement which

will be successful under the first condition will necessarily be just as successful under the second. In fact no other structural product is available which is as adaptable and as flexible in use as portland cement, which will approach it in being so successful under these two widely different conditions. That we do need studies for making cement still more adaptable is realized when we examine roads or massive retaining walls or foundations or stuccos. In the first and last instances, we are confronted very often with a large number of shrinkage cracks which furnish a very unsightly appearance and would seem to mark a condition which may be conducive to ultimate failure. Careful use of the proper aggregates and careful placing unquestionably reduces this condition, but it occurs even under the most careful cases of application so frequently that it must be considered as produced by some inherent quality of the cement.

Again there is no question but that if we made an intensive study of the materials we are using in these cases and the conditions under which we are using them and the conditions of service under which they are used, we would be on a fair way towards eliminating these faults. But suppose we have referred to us a bad case of cracked road or checked stucco and it is necessary to make a diagnosis of the trouble. Let us examine the data which we will have available to work upon. First, we are told that the cement passed the standards of the Government and of this Society. That is good so far as it goes, but actually it goes only so far as to lead us to say, in racing parlance, "cement was left at the post." It should not be inferred that we are decrying the standards. We are simply stating that for the purpose at hand they are inadequate and they are so because they are not designed to cover service under all conditions. Second, we may have furnished us a granulometric analysis of the aggregate. This again is good, but what does it represent? A sample taken during the preliminary survey of suitable material to enable a choice to be made of the best aggregate or the average of a few analyses made during the course of the work or even, in extreme cases, the result of daily analyses. In any case, what was done with the analyses? Was any regrading made, or, more vitally, were any tests made to find out how the aggregate, as available or regraded, acted in respect to volume changes during setting and hardening? Third, how much water was needed for a good consistency and how much was actually used; not how much was the foreman told to use but how much did he use *by actual measurements*? Other data of course are needed—temperature, humidity, precipitation, etc.—but when we come to use the data, invariably laboriously collected, it is found to be so decidedly lacking in one respect or another that deductions of uncertain value can only be made. Acknowledging the existence of many jobs which have given and are giving adequate service, we are confronted with those that have not; and for the elucidating of the reasons for the failures of these a series of observations should be made on a number of jobs in course of installation by trained testing (not constructing) engineers. These should be supplemented by a series of tests on materials as used, and by a number of corollary tests to determine what would happen if they were used in other manners and under other conditions. These tests must be more exhaustive than now used. Our "standard" tests for cement will not tell the whole story. The character of the grading of the aggregates and strength tests of the concrete are also insufficient. Our present methods only very roughly approximately enable us to predict the suitability of a concrete for any particular use.

Some time must be devoted to concrete in founda-

tions, tunnel linings and other cases where it may be subjected to percolating waters. Briefly, concrete through which water *constantly* percolates is doomed, but only locally at that point where the percolation takes place. We can deduce this from the conditions in any large limestone section of the country, where in many cases streams of water, once on the surface, are hundreds of feet underground, and as a consequence of which, we have the many beautiful caverns sometimes characterizing such locations. Hydrated cement, the matrix of concrete, is just as soluble as limestone, in fact it is more soluble. It has been found by sad experience that water must be kept out of concrete and it is being done on all large jobs. With the prevention of the water percolating through the concrete, the latter is giving adequate service. But cement in itself can not be so changed as to make the concrete impermeable. Here is a condition which requires the joint proper use of all the ingredients of concrete, cement, aggregate and water, and when so used an impermeable concrete can be obtained.

CLASS III.—CONDITION OF EXPOSURE

Concrete when subjected to the action of the solution of certain salts, especially sulfates, has been found to give a service which has been adversely criticised. Yet we are compelled to believe that the same relative degree of service is obtained under these conditions as is obtained in certain other cases where the life of concretes has been the subject of attack, that is, it gives a far greater service and return on the investment of installation than any other material that might be substituted for it at less, equal or greater cost. Here is a case where concrete would not be so severely criticised were it not for those adherents who insist that it will be permanent, but who should only more rightly insist that it will be more permanent than any competitive product.

It is not within the scope of this paper to refer to any of the many papers or investigations which have been given to the public discussing the matter of the corrosion of concrete by sea or "alkali" water. Many of these are but useless wastes of printer's ink, as they are solely expressions of opinion based upon few or no observations and very faulty hypotheses and unfortunately have created many false impressions. Others of these have been of some value in citing observations with due attention being paid to conditions and in discussing all of the history of the installation in so far as it can be obtained. A very few have been of extreme value in that they have attempted to make deductions from the observations of concretes very closely examined, not only as regards conditions but also as to history, and have supplemented their deductive studies with more or less inductive research. But even the best of these can be considered only as very preliminary studies and largely as suggestive of lines which should be followed in future work.

Again we feel that the major part of such studies must be confined to the cement. If we have a matrix unaffected or but very slightly affected by these solutions, then we must of necessity assume that we would have reached the ideal condition or at least have it in sight. For we now know enough about the quality and the grading of aggregates needed for such work to be able to make the proper choice in this respect without further study. But we have such a meager amount of information in regard to the resisting qualities of cement to such salt action that this field of

study may be considered a virgin one. However, we must start not with the cement as it reaches the market, but go to the plant and still further to the quarry. We must know its entire history just as much as we must know the entire history of the concrete—assuming as is generally but erroneously done that the history of concrete starts with the delivery of the cement and aggregates to the job. We must know not only that it is a certain brand made at a certain plant but we must also know from actual observation how and from what it was made and this detailed knowledge must be obtained by some keen observer more skilled in making such observations than in making cement. We must know not only the amounts of the elements present in the clinker but also how they are combined and the amounts of these combinations. In addition we must know the character of the development of these combinations, whether they have developed only incipient crystallization or whether they are distinctly and coarsely crystalline whether they have fused into a hard, almost glassy clinker or into a porous coke-like one. We must know something "real" about the fineness of the cement made from the clinker, not solely the 200-mesh fineness, but the actual "grading" of the cement particles and an idea of the angularity or roundness of the cement grain. Then we must have tests of the cement which will give us values which are indicative of the different behaviors which cement reveals in service. However, when we have all these data we are only in the position to make concrete and feel assured that we have on file some observations which have in other cases been overlooked but which are essential. In the meantime investigations must be under way which will have for their purpose the determination of the course and the products of the reaction which takes place between the constituents of cement and water, how these are affected by the various solutions with which cement may come in contact and how the reaction may be affected by various proportions of the constituents or by the different physical characteristics under which they may exist.

There is no question but that a deductive study of concrete forces us eventually to conclude that we are grossly ignorant of cement; what it is as produced on a plant scale; what variations in ultimate quality we must expect in any plant's production from day to day; what is the nature of the reaction with water and how this reaction will deport itself in a variety of atmospheres and solutions. Some intensive work must be done that will solve these questions and enable us to produce the exact kind of cement we want at any time after having found out the kind of cement we must have for the case in question. There is no gain-saying the fact that cement as now produced, and known as imperfectly as it is, is giving us in by far the great majority of cases most adequate service. But while innumerable successes will cause no annoyances or concern, one failure may offset all the successes. And acknowledging that we are using cement as intelligently as we now know how, are we getting out of it all or even a majority of its potential qualities? The cement producers are assured we are not, the cement user feels that he is doing the best that general job conditions will permit, but what an assurance and relief it would be both to know exactly which is right and to what degree.

Our title also calls for a discussion of investigations of plant methods in addition to a discussion of the properties of cement as we now have it made according to the usual plant routine. This phase of needed researches could be developed to far greater length than

⁴In this connection "alkali" is generally erroneously used. The "white alkali" of arid sections is usually either an impure sodium sulfate or an impure mixture of sodium and magnesium sulfates and is but infrequently alkaline. The "black alkali," which may be white when dry, is an impure sodium carbonate; it is, however, noted in but relatively limited areas.



FIGS. 1 AND 2—AT THE LEFT, THE PICTURE IS A TYPICAL VIEW OF THE OLD STREETS OF CANTON AND AT THE RIGHT THE NEW WIDE-PAVED THOROUGHFARES

China Overthrowing Antiquity

BY ROY ALDEN

Particularly impressive to the observer of China's gradual acceptance of Western ideas and ideals is the construction of wide paved streets in many of the largest and oldest cities of the Oriental Republic, which until recently were the strongholds of Oriental antiquity in its most pronounced form.

Canton presents a striking instance of the big things that are happening in this land of 400,000,000 souls. It is the chief commercial and distributing center of South China; the first Chinese city to tear down its crumbling walls and replace them with broad streets, although many others have followed. While outdistanced from the standpoint of commercial importance by Shanghai, Canton is China's largest city, and today one of its most progressive. Along with many other modern developments has been the extensive use of concrete in construction of many kinds.

Until quite recently the streets in Canton were so narrow that with both hands outstretched one could almost touch the walls of buildings on either side, and one salesman on one side of the street, sitting behind the counter of his shop, could carry on a casual conversation with a salesman in a store on the other side. These narrow, tortuous streets have now passed into memory. The width of the new streets in Canton is from 70 to 100 ft. and a large number of houses that were located on either side of the old walls were condemned, in whole or in part, because they were in the path of the street system. The compulsory forfeiture left countless shops of types planned two or three thousand years ago by builders who never visualized the need for wide thoroughfares, with but a few square feet of land, while others, more fortunately situated, found that the rear entrances of their places of business were to face an excellent paved road, as against the dirty narrow street fronting their main entrance.

The road building system provided for 50 ft. radius at all corners to permit street cars to turn without difficulty and new concrete structures are replacing the old bridges of granite that were crumbling from centuries of service with no repairs. China's greatest need today is transportation, a system of wide paved highways as well as a system of railroads.

Cement Manufacture Filmed

Much of the unusual equipment involved in making cement is interestingly illustrated in a two reel moving picture called "The Story of the Manufacture of Portland Cement," just released for general showing.

Starting with views of one of the large plants in which the country's cement is made, the film pictures in a non-technical way the essential steps in transforming thousands of tons of raw materials into portland cement. Scenes taken at a number of plants are included.

From the moment that a great blast breaks loose a cliff of limestone in the quarry to the time when the finished cement goes into storage in big concrete bins, the process of manufacture is almost entirely mechanical.

In addition to straight photography, animated drawings have been inserted to make clear what occurs inside the grinding mills, what goes on within the white-hot interior of the huge kilns, and how the cement sacks, suspended upside down, are filled after they have been tied.

Arrangements to show the film can be made with any office of the Portland Cement Association.



FIGS. 3 AND 4—OLD BUILDINGS ARE BEING TORN DOWN AND WATERWAYS FILLED IN; SUN & COMPANY'S DEPARTMENT STORE IS TYPICAL OF THE NEWER BUILDINGS

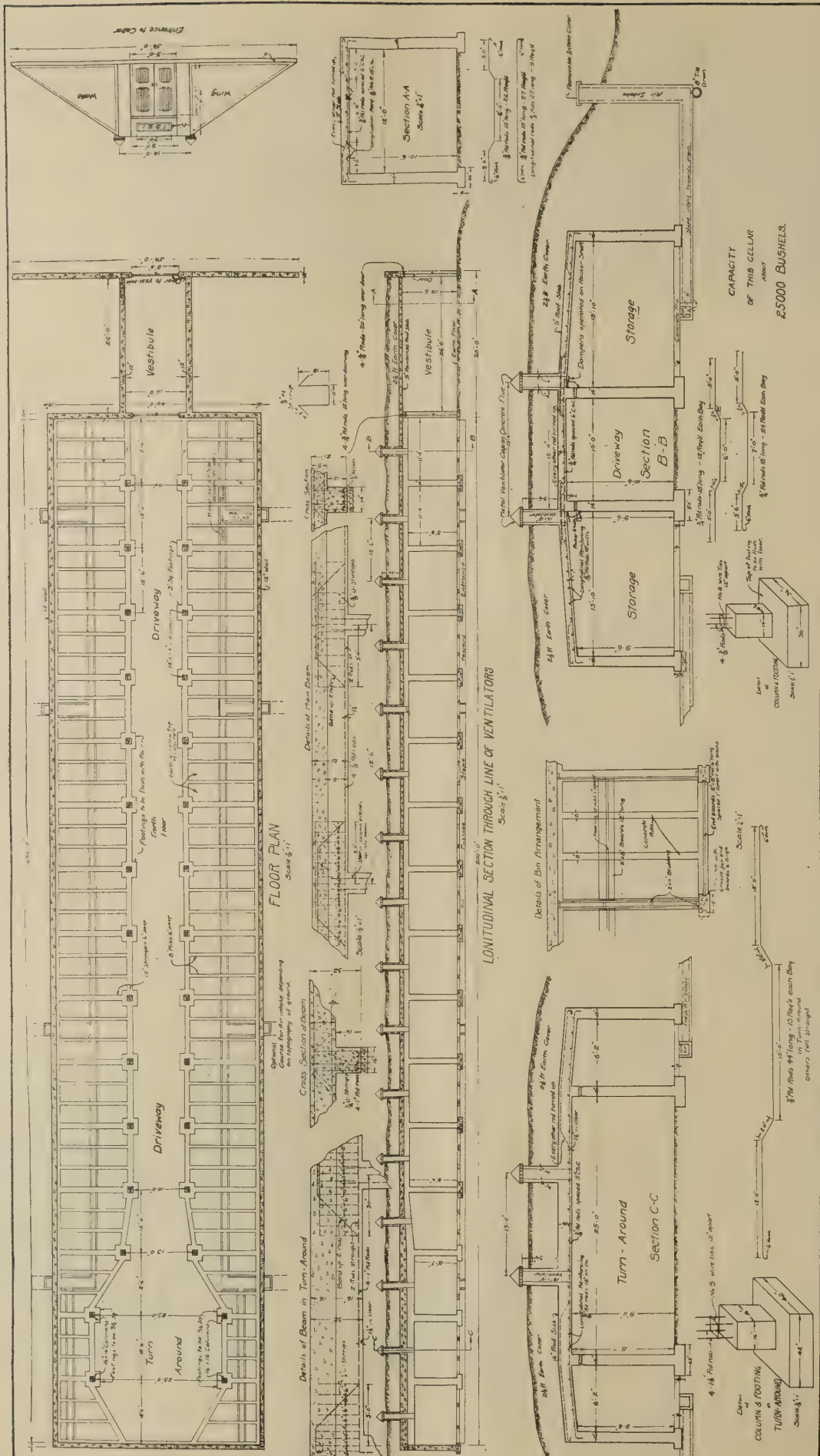


Fig. 1—DETAILS OF CONSTRUCTION OF LARGE STORAGE CELLAR

Concrete Storage Cellar for a State Institution

By EARLE D. MCKAY
UNIVERSAL PORTLAND CEMENT CO.

There are many State Institutions, each having a population comparable to a small city and raising on adjacent lands, vegetables sufficient for their use throughout the year, which are faced with the problem of inadequate or inefficient storage. Such was the case of the South Dakota State Hospital at Yankton. The solution of the problem has been so successful and so many inquiries have been received from similar institutions in regard to plans and construction that the institution wishes in every way possible to give the benefit of its experience to others.

The hospital at Yankton numbers on an average approximately 1400 inmates. It raises all of its own vegetables; potatoes being the largest crop and each fall stores from 15,000 to 25,000 bushels to take care of the requirements of the institution until the next crop. Stored in an old root cellar, it was unusual to have half the potatoes thus stored come through in usable condition the next spring. In fact, it became necessary many times to go into the market in February or March, just when the peak prices had been reached, and buy potatoes for the balance of the season. It was found to be even more difficult to store such vegetables as onions, cabbage, rutabagas, and turnips. This condition led Dr. G. S. Adams, Superintendent of the Institution to consider scientific storage and being convinced that such a cellar of concrete could be successfully designed and built he went before the Legislative Session of 1921 and secured an appropriation of \$10,000 to build such a cellar to meet his requirements. Considerable aid on storage and storage conditions was secured from the U. S. Department of Agriculture. The cellar as built, is much larger than any heretofore constructed.

Trucks or garden wagons may enter and leave the cellar while a twenty-six foot vestibule protects the contents from outside differences of temperature. The main cellar is 200 feet long and 42 feet wide (Fig. 1) and is arranged in a series of bins so that it is possible to store vegetables in a large number of comparatively small compartments, or by combining several bins to get a larger storage space. The side of the bin next to the driveway is provided with end boards which fit into a groove in the concrete column. This is shown in Fig. 2. Since vegetables other than potatoes require different storage conditions, the end of the cellar can be partitioned off. Fig. 3 shows a view of the turn-around with onion racks around the walls. A number of other vegetables are stored in this end of the cellar.

Ventilation is provided by means of out-take flues from the top of the cellar, while fresh air enters beneath the bins and comes up through the stored vegetables. Ventilators are provided on the out-take flues and operate as a unit to regulate the amount of air circulating through the cellar. Fig. 4 shows the ventilators above ground. The entire cellar is covered over with 2½ feet of earth and this is seeded down and used as a hog run.

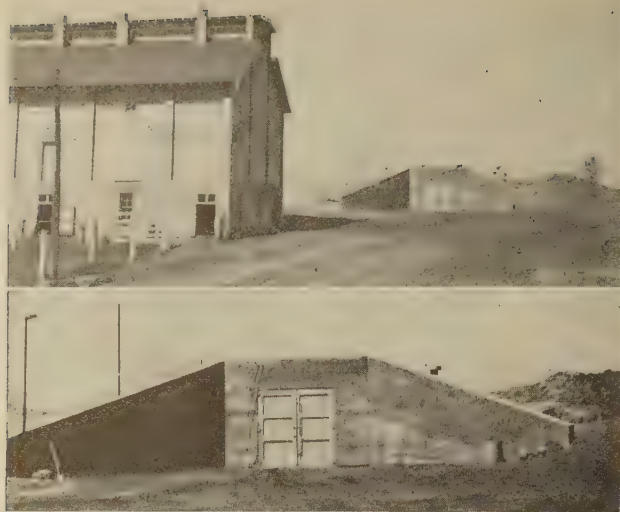
The design of the structure presents no unusual problems. Outside of its size and provision for admission of fresh air under the vegetables, the only unusual feature is the turn-around, necessitated by



FIG. 2—BINS FOR POTATO STORAGE
FIG. 3—RACKS FOR ONIONS AND ROOT VEGETABLES
FIG. 4—SHOWS DOUBLE LINE OF VENTILATORS EXTENDING ABOVE GROUND
FIG. 5—CONCRETE MIXING PLANT AND CAR ON TRACK
FIG. 6—PLACING CONCRETE FOR ROOF OF TURN-AROUND

the side hill site. The concrete stringers keep the vegetables off the ground preventing dampness and mold.

This structure was built by inmate labor. Washed and screened cinders were used as aggregate and mixed



FIGS. 7 AND 8—ENTRANCE TO STORAGE CELLAR—FIG. 7 ALSO SHOWING ANOTHER CONCRETE BUILDING OF THE YANKTON INSTITUTION

1:2:4, the fine aggregate passing a $\frac{3}{8}$ -in. screen and the coarse passing $1\frac{1}{2}$ -in. A car running on a track

as shown in Figs. 5 and 6 carried the concrete from the mixer. The slump test was used in determining consistency, a 4-in. slump being the maximum permitted. The entrance to the finished structure is shown in Figs. 7 and 8.

The cellar was not completed in time for the 1921 crop but was filled in the fall of 1922 with 20,000 bushels of potatoes, 600 bushels each of onions, beets and rutabagas. Eight hundred barrels of sauerkraut stored in large vats were also placed in the cellar and can be seen in Fig. 2. Everything came through the winter in excellent condition. In April 1923, Dr. Adams stated that they had picked over what remained of the potatoes and less than 100 bushels were thrown away and practically all of these had been bruised in digging. The temperature of the cellar was kept between 33 and 35° F. by regulating the ventilators. Tests were conducted during the winter by ventilation experts who were interested in the installation, and they found a good circulation of air. It was found that the storage of sauerkraut in the same cellar with potatoes created a dampness which was objectionable. A change is therefore being made and a space between the parapet wing wall and the main part of the cellar on both sides is now being excavated and with entrances into the vestibule will in the future contain the sauerkraut vats.

Integral Waterproofings for Concrete

BY ALFRED H. WHITE

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Presented before the 15th Annual Meeting of the American Institute of Chemical Engineers, Richmond, Va., December 6 to 9, 1922. Reprinted from *Industrial and Engineering Chemistry*, Vol. 15, No. 2, page 150, February, 1923.

Deals with the properties of concrete and of integral waterproofings, not as used under conditions where the concrete is always kept wet, but where the concrete is frequently dry and may never have had adequate opportunity to have its colloid developed. The paper limits itself quite closely to a discussion of the rate of absorption of water by capillary action and the effect of integral waterproofings on the rate of water absorption. The results set forth were obtained by observations on blocks 4 x 4 x 6 in. made from a single lot of sand and with cement from well-recognized commercial brands. The sand was clean, natural sand of good quality. The blocks were all made from a 1:3 mix with about 10% of water. The tests are selected from a total of ninety-eight involving differing materials and different methods of treatment.

The conception of concrete held by the majority of engineers and users is that it is a mixture of portland cement and inert aggregate which on reaction with water becomes a dense and hard mass, expanding and contracting with changes of temperature in about the same ratio as steel but otherwise unalterable in volume and permanent if properly made and not exposed to any action other than that of water and air. It is now definitely established that concrete shrinks whenever it becomes dry and expands whenever it becomes wet, irrespective of its age when tested, and that, furthermore, these changes in volume are much larger, more rapid, and more frequent than those due to temperature changes¹. These changes when concrete is alternately wet and dried may amount to as much as the equivalent of a temperature change of 200° F.

REACTIONS OF PORTLAND CEMENT AND WATER

The process of hardening portland cement is as follows: Each grain is surrounded by liquid water which attacks the surface of the grain, decomposes it, and forms hydrated compounds—silicates, aluminates, and hydrated lime—some of which are amorphous and some crystalline. The amorphous bodies are colloids,

which swell in contact with water and shrink when water is abstracted.

Concrete retains these properties of a colloid to an undiminished extent for at least twenty years. The reaction between the grains of cement and the water is so slow that it requires months or years for its completion. In a rich cement mortar the reaction stops only because the colloid has swollen to such an extent that no more water can force its way in to react with the unchanged kernels of cement. The pressure of this swollen colloid is enough to cause an increase in length of 0.15% in bars of neat cement, and of expansion one-half as great in mortars of 1:3 composition. This expansion in 1:3 mortars is equivalent to a compressive stress of 1500 lbs. per sq. in. Concrete that is properly made in a fairly rich mixture and thoroughly hardened under water will not permit any water to pass through it, because the swollen colloid closes all the capillary pores. Such a concrete when thoroughly swollen will contain no liquid water, but only colloid water, or water of crystallization. If one surface of this concrete is in contact with water and the other in contact with freely circulating air, as frequently happens in a dam or reservoir, the concrete will appear absolutely tight. No water will seep through it. If, however, the air should be relatively dead, as in a cellar or basement, it would be found that the humidity of the air in the cellar was very high. Moisture would evaporate from the apparently dry surface of the concrete and be replaced by moisture diffusing through the colloid of the concrete. If the water were drained from the reservoir, in the case cited above, the concrete wall would lose water by evaporation from the colloid and shrink so that after a few weeks it would be porous. If the concrete wall were several feet in thickness this phenomenon might not be noticed, but in a cellar wall

¹White, *Proc. Am. Soc. Testing Materials*, 14 (1914), 203: "Materials of Construction" *Trans. Inter. Eng. Congr.*, 1915, 242.

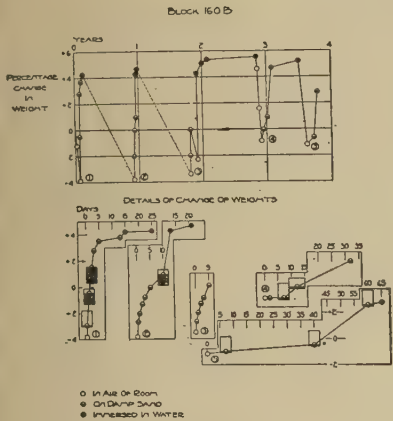


FIG. 1

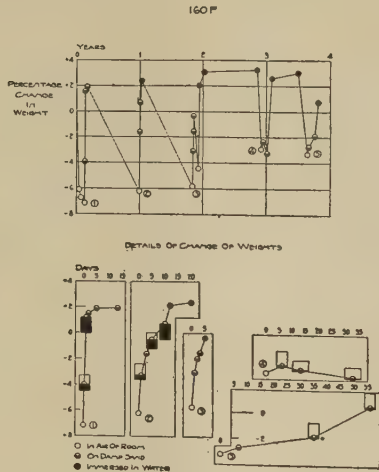


FIG. 2

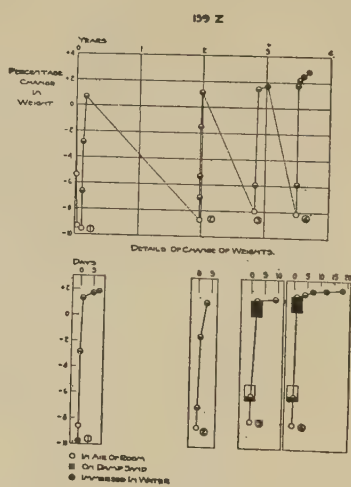


FIG. 3

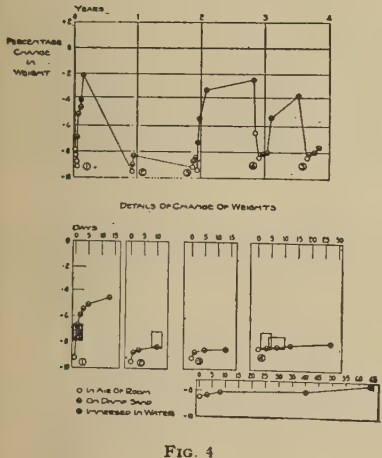


FIG. 4

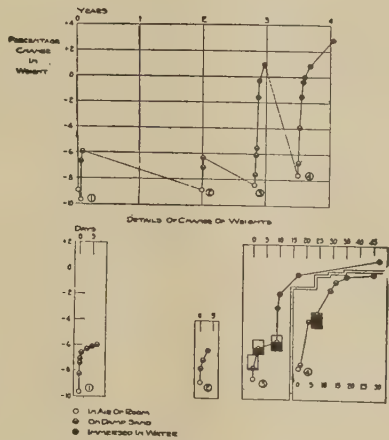


FIG. 5

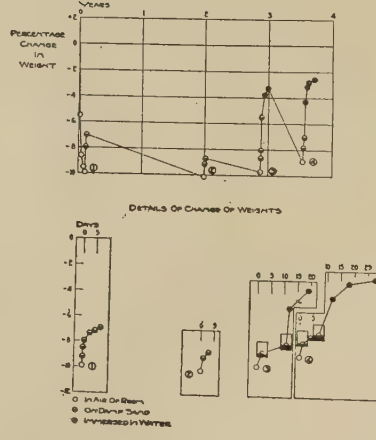


FIG. 6

about 12 in. thick it might be very apparent. If water should again be brought in contact with one side of the wall, the pores in the concrete would rapidly fill with water, owing to capillary action, and the inside of the wall would appear damp. It might even allow water to percolate through it for a few days until the dehydrated colloid had again absorbed water and become swollen so as to shut out further ingress of water. It has been the tendency of engineers to test concrete when it is wet and most of the results that have shown concrete to be waterproof have been made on concrete with its colloid fully swollen.

WATER ABSORPTION BY MORTARS WITH NO WATER-PROOFING AGENT

The behavior of a block of 1:3 mortar without water-proofings is shown in Fig. 1. This block, 160 B, was made from 1 volume of Universal cement, 3 volumes of sand, and 1 volume of water. It was mixed by hand and placed in a metallic mold 4 in. square and 6 in. deep. After 12 days in the mold it was removed and allowed to dry 21 days in the air, during which period it lost 3.87 % in weight. It was then placed in a box containing a layer of damp sand with a constant water level $\frac{1}{4}$ in. below the surface of the sand. The block was placed on end on the surface of the sand and the box was covered with a cloth so that evaporation was largely restricted. During 13 days on damp sand the block gained 8.1 % in weight. Detail 1 in the lower part of Fig. 1 indicates the rise of moisture

in the block. After 9 hrs. moisture had risen 4 in. out of the total 6, and at the end of 24 hrs. the top of the block was moist. At this time the weight was 0.54 % less than the initial weight of the block when it was removed from the form. The capillaries were not, however, completely filled with water, for the block continued to gain weight at a decreasing rate, until after 13 days its weight had increased to 3.75%. It was then immersed in water and in 10 days increased only 0.5 % more. It is thus apparent that a cement mortar, even as rich as 1:3, which is allowed to dry out when removed from the forms, is highly absorptive.

This block was then allowed to stand in the air of the laboratory for 9 mo., when it was again placed on damp sand. Its dry weight was practically the same as in the previous year, but it only absorbed a little over one-half as much water and the moisture only climbed $4\frac{1}{2}$ in. in ten days, whereas in the preceding year it had climbed 6 in. in one day. On immersion in water for 10 days the weight increased to an even slightly higher figure than it had reached in the preceding year.

This block was then again dried for 10 mo. in the air, when it returned to nearly the same dry weight which it had shown originally. When placed on damp sand it absorbed moisture at substantially the same rate as before.

It was then determined to try the effect of a longer immersion in water. During this immersion its weight increased slowly through hydration of cement that had

not been previously attacked. When dried 25 days in the air after 11 mo. immersion in water, it retained almost as much moisture as it had held when it was first removed from the mold. This is a clear indication that the colloid had developed by the 11-mo. immersion in water. When this block was now placed on damp sand, the moisture climbed only $\frac{3}{4}$ in. in 6 days. The block was then laid on its side instead of its base, but the water climbed only $\frac{1}{2}$ in. The block was again immersed in water for 5 mo. and then kept in air for 45 days, when it was again placed on damp sand. The moisture only rose $\frac{1}{2}$ in. in 40 days and the change in weight was almost negligible. It was evident that for some reason the moisture was no longer rising in the block. The question then arose as to whether the resistance to the absorption of water was in the skin of the block or was uniform throughout the entire mass. To determine this point, about $\frac{3}{8}$ in. was rasped off the bottom of the block and it was again placed on damp sand. Its behavior is shown in Detail 5 of Fig. 1. The block now absorbed moisture slowly until its total increase in weight was greater than it had been on its first test when the water had reached the top of the block. Notwithstanding this fact, the surface of the block remained entirely dry except for the damp line about $\frac{1}{4}$ in. wide at the bottom of the block. The conclusion is that the nonabsorptive properties resided largely in the skin of the block. The earlier test had shown that the side of the block was not more permeable than the base of the block so that it could not have been due to any accidental contamination with oil or other water-repellent material on the base of the block.

The explanation may be easily found from consideration of the theory. One of the products formed by reaction of portland cement and water is hydrated lime, which is relatively soluble in water. When the block with its pores filled with water is allowed to dry in the air, it is not pure water but a saturated solution of calcium hydroxide that travels to the surface of the block. This becomes converted to calcium carbonate through reaction with the carbon dioxide of the air and the calcium carbonate thus deposited seals the capillary openings just as on a larger scale it stops up the tubes in a steam boiler. The surface of fairly rich concrete which is alternately wet and dried will therefore waterproof itself in time through deposition of calcium carbonate. The waterproofing will, however, reside mainly in the skin, and the center of the mass will still have capillary openings. These capillary openings will be smaller in old concrete which has had long immersion in water, because they have become partly filled with colloid. Dry concrete will, however, always have capillary canals.

EFFECT OF WATERPROOFING MATERIALS

HYDRATED LIME—The effect of hydrated lime is shown in Fig. 2, which is a study of a block made from 1 volume cement and 3 volumes of sand, to which was added 0.1 volume of high, calcium hydrated lime for each volume of cement. This block, 160 F, was kept two days in a metal mold, then dried in the air of the laboratory for 38 days and placed on damp sand as before. The absorption of water was about three times as rapid as in the case of the mortar to which no lime had been added. After 10 mo. in air the test was repeated and the absorption found to be distinctly slower than at first. After the block had stood 11 mo. in water and had been afterwards dried for 28 days in air, a repetition of the absorption test showed very little increase in weight. (Detail 4 of Fig. 2.) When the block was placed on its side instead, it actually lost weight because of the better conditions for evaporation. After another period of 5 mo. in water and subsequent drying, there was very slow absorption. When, however, after 35 days on damp sand the outer skin of the base was rasped off, the weight increased much more rapidly. (Detail 5 of Fig. 2.) The final waterproofing was due largely to deposition of calcium carbonate in the pores of the surface, as in the previous case. The first effects of hydrated lime are distinctly unfavorable from the waterproofing standpoint. Hydrated lime is a water-absorbent colloid and the addition of this material promotes absorption of water

until such time as the surface pores become filled with calcium carbonate.

CLAY—The effect of clay is shown in Fig. 3, where the history of Block 159 Z is traced. This was made from 1 volume of cement and 3 volumes of sand, with the addition of a plastic clay to the extent of 15 % of the weight of the cement. The clay caused an absorption even more rapid than hydrated lime on the early tests, which persisted even on the later tests, as shown in the details of Fig. 3. This block only received an immersion of 2 mo., so it is not possible to say whether it would ultimately have become nonabsorbent. Clay certainly makes a much poorer showing than hydrated lime, which in turn does not make so good a showing in its earlier career as the mortar containing only cement and sand.

EFFECT OF PETROLEUM RESIDUA—The influence of petroleum residua of various sorts was tested and Fig. 4 represents a typical case. Block 160 T was made from 1 volume of cement and 3 volumes of sand, with the addition of a mixture of mid-continent, semi-asphaltic flux, thinned with 10 % of its weight of benzene to make it more miscible. This diluted flux was used in the proportion of 11 % of the weight of the cement. The block was dark in color and had a petroleum odor.

The water absorption on the early tests was distinctly slower than in the cases previously discussed, although the moisture rose to the top of the block on the first test. The second and subsequent tests showed very efficient damp-proofing. Even after the bottom of the block was rasped off on the fifth absorption test, the increase in weight was very small. An objectionable feature was noted in the diffusion of the oil out of the block. After the block had stood for several days on damp sand, the sand would be black from diffused oil for a depth of $\frac{1}{4}$ in. below the block.

EFFECT OF INSOLUBLE SOAPS—The insoluble soaps tested as waterproofing agents were prepared in the laboratory by precipitation, washing, and drying. This had the advantage of the use of a definite product but the disadvantage of the difficulty in mixing it with the water. The soaps were distinctly water-repellent and did not lend themselves as well to incorporation as some of the commercial compounds specially prepared to emulsify readily with the mixing water.

The behavior of calcium oleate as a damp-proofing agent is shown in Fig. 5, which shows the behavior of Block 159 B made from 1 volume cement, 3 volumes of sand, and calcium oleate to the extent of 1 % of the weight of the cement. This dry calcium oleate was flocculent and did not emulsify readily. The water-absorption tests showed distinctly less absorption than the blocks that did not contain water-repellent material. This block did not receive any immersion to develop its colloid until the end of the third year, and then it was kept only 30 days in water. After drying it was again tested for water absorption and it increased in weight slowly until, after 7 days, the water reached the top of the block. It was then put into water for a longer time, but unfortunately the test had to be interrupted at that point.

The effect of aluminium stearate is shown in Fig. 6. Block 159 F was made, like the others, from a 1:3 mix, with the addition of aluminium stearate to the extent of 1 % of the weight of the cement. An attempt was made to emulsify the aluminium stearate with dilute ammonia, but with only partial success. The tests parallel those with calcium oleate shown in Fig. 5, but are in general more favorable, perhaps due to the better emulsification of the aluminium soap.

COMPARISON OF WATER ABSORPTION

A comparison of the behavior of these blocks during their first absorption period is given in Fig. 7, where the rate of water absorption of the air-dried blocks when placed on wet sand is plotted. It will be noted that the three blocks with the insoluble soaps and with petroleum incorporated show roughly only half the absorption of the plain mortar, which in its turn makes a distinctly better showing than the blocks containing hydrated lime or clay.

INFLUENCE OF INTEGRAL WATERPROOFINGS ON STRENGTH

The question of strength of mortar and concrete treated with integral waterproofing is of prime importance. Abrams² reports that hydrated lime and clay both weaken concrete to a rather small extent. The experiments described in the present paper do not warrant the consideration of hydrated lime and clay as damp-proofing agents. The effect of water-repellent, integral waterproofings on strength has not had the same recent and careful study which Abrams has accorded the others. The action of insoluble soaps was carefully studied at the Bureau of Standards.³

²Proc. Am. Soc. Testing Materials, 20 (1920), II, 149.

³Bur. Standards, Tech. Paper 3 (1911).

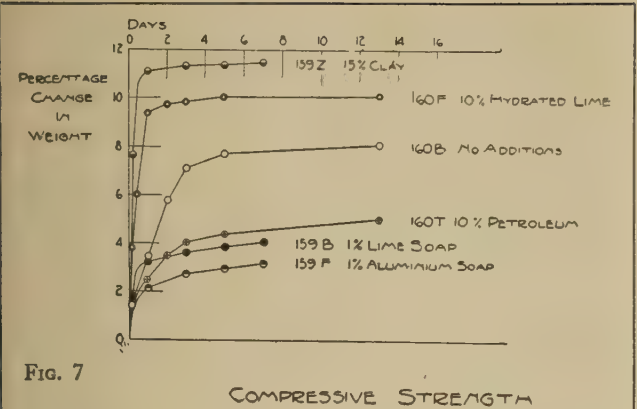


FIG. 7
COMPRESSIVE STRENGTH

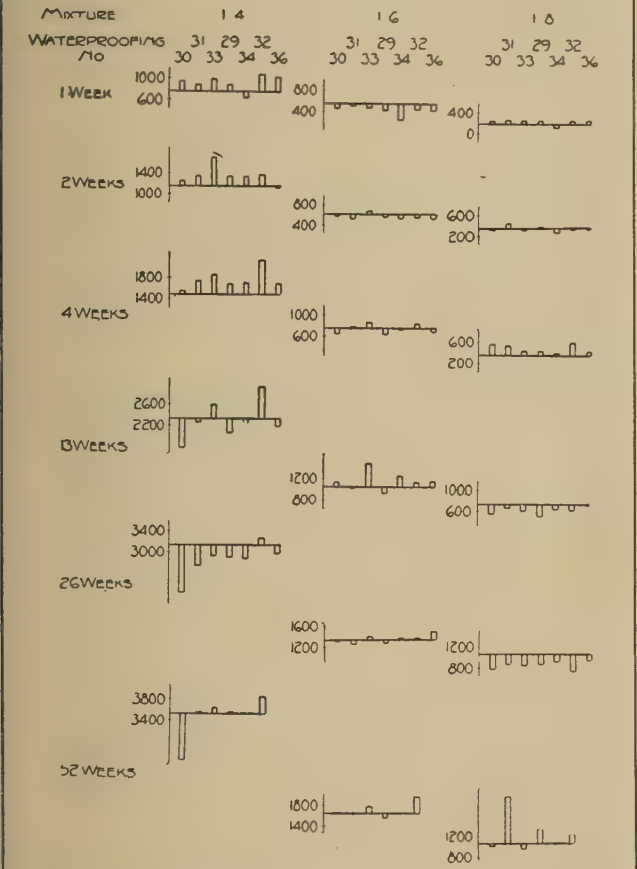


FIG. 8—THE HORIZONTAL LINE SHOWS THE STRENGTH OF THE CONCRETE TO WHICH NO ADDITIONS HAVE BEEN MADE. THE RECTANGLES SHOW THE DIFFERENTIAL STRENGTH OF THE SPECIMENS CONTAINING WATERPROOFINGS

Both tensile and compressive strengths of mortar of varying richness containing commercial waterproofings, whose chief constituent was an insoluble soap mixed with dry hydrated lime, were included in this report. These investigators drew the conclusion that the strength was not seriously affected by the compounds used. There were seven of these waterproofings containing insoluble soaps and the amount of fatty acid varied from 0.064 to 0.78 % of the weight of cement used. It is very difficult to get a clear picture of the effect of these compounds from the long tables given in this paper, and in order to give a visual picture of this effect the results have been plotted in Fig. 8. In this figure the compressive strength of the non-waterproofed specimen has been shown by horizontal lines. The variation of the samples containing waterproofings is shown by rectangles extending above or below these horizontal lines. The waterproofing agents

are arranged in increasing order according to their fat-acid content. The figure may be further explained as follows: The first column of Fig 8 shows the compressive strength of blocks of 1:4 mix kept damp for varying periods. The average compressive strength of the non-waterproofed specimens tested when one week old was 750 lbs. per sq. in. Six of the seven waterproofed specimens showed a higher compressive strength than the mortar with no additions. The highest figure, for No. 32, was 1096 lbs. A similar picture was presented at the end of 2 wks. and of 4 wks. In testing at the end of 13 wks., 2 waterproofed samples showed better than the non-waterproofed and 4 did not show so well. After 26 wks. only one of the waterproofed samples showed a better strength than the non-waterproofed. At the end of 52 wks. only 5 samples were tested, and 4 showed higher strength than the non-waterproofed mortars.

The compressive strength of the 1:6 and 1:8 mixes, as shown in the second and third columns of Fig. 8, reveals much the same picture. It must be remembered that the base line is the compressive strength of the non-waterproofed mixtures and that any error in this base line would distort the whole series in which that particular test was used as base. Judgment must therefore be formed on the picture as a whole. The tests on the leaner mixes 1:6 and 1:8 show, with a few exceptions, rather slight variations from each other and from the non-waterproofed samples. Tests on the 1:4 mix show uniformly greater strength at 1, 2, and 4 wks. The results at 13 wks. scatter, those at 26 wks. are inferior to the non-waterproofed samples, while 4 out of the 5 waterproofed samples tested after 52 wks. were stronger than those not waterproofed. This considers all the different waterproofings as being of equal merit, which, however, is hardly fair. The mixtures containing waterproofing No. 30 only contained 0.066 lb. of fatty acid for each 100 lbs. of cement. This mixture No. 30 gives inferior results. On the other hand, the mixtures containing waterproofing No. 32, which contained 0.75 lb. of fatty acid for each 100 lbs. of cement, showed distinctly higher compressive strengths than the non-waterproofed samples of the 1:4 mix at each one of the 6 test periods.

The author has not made nearly as complete a series of tests of strength as those reported by the Bureau of Standards, but he has been puzzled to find similar instances of higher strengths on the part of mortars containing small amounts of insoluble soaps. It is not easy to see why insoluble soaps should increase the strength of mixtures kept constantly wet or damp, as was the case in the tests of the Bureau of Standards. It is, however, possible to see how any type of water-repellent, integral waterproofing may increase the strength of concrete or mortar left in air after removal from the mold. A water-repellant material diminishes the flow of water to a dry surface by capillary action in the same way that it diminishes absorption from a wet surface. Therefore a block of mortar containing a water-repellent material will not dry out as rapidly as one which does not contain such a material. It should, therefore, have a better opportunity to develop its colloid and should show higher strengths, especially at the end of 7 and 28 days in air.

Index to CONCRETE, Vol. 22, January to June, 1923, will be sent to subscribers who ask for it.

The Strength of Alcement Reinforced Concrete

BY J. BIED

After *Revue des Matériaux de Construction et des Travaux Publics*.

J. Bied was formerly engineer in charge of the laboratories of the Cement and Lime Co. of Lafarge and Teil, which first produced Ciment Fondu, with its associates—Ciment Electro-fondu and Ciment électrique—all of which come under the head of "Alcement," a cement which now is attracting universal attention owing to its rapid hardening and remarkable strength.

The general composition of the "Alcements" is

Silica.....	10 to 12%
Aluminates.....	40 to 45%
Lime.....	35 to 40%
Iron oxide.....	15 to 20%

The set of Alcement commences at about 4 hours and ends at 7 or 8 hours and the hardening progresses rapidly until at 72 hours the strength of a 1:1¾:3½ mix reinforced concrete beam is 4,250 lbs. per sq. in., or far greater than a corresponding beam made of portland cement concrete.

This great strength and the fact of the rapid hardening, reduce the dimensions required, the amount of form lumber and the time of construction, as the forms may be removed the third day.

Certain precautions are, however, essential in the use of Alcement:

1. Concrete or mortar must not be too dry, and the forms must be well wetted.
2. The concrete must set before any finish is applied.
3. The mortar must not be very fat—never more than 2¾ bbls. of Alcement to the cu. yd. of sand.
4. Great care must be exercised that no admixture of lime or portland cement takes place, even in the slightest degree; the mixer, the buggies and all tools must be carefully rinsed and cleaned before coming in contact with the concrete.

The hardening of the Alcement concrete, contrary to all other cement concretes, starts in the interior of the mass and works outward to the surface, so at times the latter may appear soft to the depth of 1/8 in. to 1/4 in. while the body itself is perfectly hard.

The computations of strength are based upon the following assumptions:

1. A plane section before bending remains plane after bending.
2. Concrete and steel are stressed proportionally to their moduli of elasticity.
3. The modulus of elasticity for steel is the same in compression and tension.
4. The modulus of elasticity for concrete is an assumed fraction as between tension and compression,—this ratio is expressed by the letter n .

The other notations are those selected by the French Department of Public Works:

- m = Ratio between moduli of elasticity of steel and concrete.
 b = Breadth of beam.
 H = Depth of beam.
 y = Distance from the neutral axis to maximum compression fibre.
 d = Distance from center of compression area W to the maximum compression fibre.
 d' = Distance from the center of tension area W' to the maximum tension fibre.

H' = Distance from center of tensile reinforcement to the maximum compression fibre.

$R'a$ and $R'a$ = Ultimate strength of the steel in compression and in tension.

Rb and $R'b$ = Ultimate unit strength of the concrete in compression and in tension.

M = Bending moment.

I = Moment of inertia of the beam.

1. Reinforcement in tension only:

Equilibrium between compression and tension demands that

$$\frac{by^2}{2} - \frac{b(H-y)^2}{2n} - mW'(H'-y) = 0 \dots\dots\dots 1$$

$$2 \quad \frac{2n}{mR_b} = \frac{y}{R_b H - y} \dots\dots\dots 2$$

Between the ultimate unit stresses of the two materials the following relations exist:

$$\frac{R'a}{mR_b} = \frac{H'-y}{y} \dots\dots\dots 2$$

$$R'b = \frac{1}{2} \frac{ny}{R_b H - y} \dots\dots\dots 3$$

Finally, the bending moment is:

$$M = \frac{bR_b(H-y)^2}{2ny} \times \frac{2}{3} H + \frac{R_b y}{y} \times mW'(H'-y)(H'-\frac{y}{3}) \dots\dots 4$$

Hence we have 4 equations with the following unknowns:

$R'a$, Rb , $R'b$, H , H' , b , y , W' and M .

For a given beam, H , H' , b and w' are known and for a given load we have M —hence we can solve for y and the unit stresses.

If we want to compute the beam for a certain load we might take

$R'a$ at 17,400 lbs. per sq. in.
Rb " 2,220 " " " "
$R'b$ " 355 " " " "

These values are somewhat high under ordinary circumstances.

A more conservative assumption would be 1,450 lbs. to 1,540 lbs. for Rb and 170 to 213 lbs. for $R'b$.

2. Reinforcements in both tension and compression:

Our first formula here becomes:

$$\frac{by^2}{2} + mW(y-d) = \frac{b(H-y)^2}{2n} + mW'(H'-y) \dots\dots\dots 1$$

and the others:

$$\frac{R'a}{mR_b} = \frac{H'-y}{y} \dots\dots\dots 2$$

$$mR_b = \frac{y}{R_b H - y} \dots\dots\dots 3$$

$$R'b = \frac{1}{2} \frac{ny}{R_b H - y} \dots\dots\dots 3$$

We introduce the moment of inertia and consider that

$$R_b = \frac{My}{I} \dots\dots\dots 4$$

and then have

$$I = m(H'W'-y)^2 + mW(y-d)^2 + \frac{by^3}{3} + \frac{b(H-y)^3}{3n} \dots\dots 5$$

which 5 formulas solve the problem, when we assume values for m and n based upon actual tests.

Under ordinary conditions, where $R'a$ is 17,400 lbs. per sq. in., the value of m becomes 7.5, and the value of n would vary between 4 in. for a 12-in. to 18-in. deep beam to 6 in. or more for a floor slab.

For high tension steel reinforcements we would assume values of m at 10, and n to be 8.

The Subgrade and Its Design

A Progress Report of the Committee on Subgrade and its Relation to Road Surfacing and Traffic of the Federal Highway Council: General Coleman du Pont, Chairman; Charles M. Upham, Vice-Chairman; Henry G. Shirley, Secretary. When the Federal Highway Council suspended operations the committee continued to function. Mr. du Pont furnished the necessary funds for the work.

Road building is now reaching its rightful place in scientific development, where the design and construction of the subgrade and foundation are commanding nearly as much attention as the design and construction of the surface. Considerable economic waste has been caused by trying to correct subgrade weaknesses by strengthening the road surface. This method has proved so conclusively wrong that much experimentation and serious study have been and are being given to design and construction of a proper subgrade.

While road surfaces on account of their characteristics are divided into standard groups, subgrade conditions are so variable and characteristics so numerous that little has been done to group or standardize subgrade designs, other than to outline a few methods of treatment—all leading in the direction of stabilizing and increasing the bearing power of the subgrade material.

It is impractical at this time, on account of the variety of conditions, to specify details of subgrade construction, yet a few facts in connection with subgrade design may be conclusively stated, viz:

1. The bearing power of nearly all soils is increased when the moisture content is decreased.
2. The bearing power is affected by moisture in some soils more than in others.

Therefore, the first two principles in the design of subgrades are the regulation or exclusion of water and the selection of a subgrade soil or material that has the highest bearing power and is least affected by moisture.

Subgrade design has for a long time been masking under the name of drainage, and in many instances the installation of pipe underdrains has been considered a cure-all, regardless of whether or not the subgrade was a drainable soil or material that would be bettered by the installation of such drain pipes.

The bearing power of practically all soils is affected by moisture, so that in designing the subgrade it is necessary to see that the material that is least affected by moisture is used. Some soils expand greatly on taking up water and shrink upon that water drying out; this effect of water proves the soil to be unstable and unsuitable for subgrades. The accompanying charts show how the addition of the same amount of water affects various soils differently, and clearly demonstrate that in selecting soil for subgrades, it is desirable to select a material that will have a high bearing value, even though it has become saturated with water. Generally speaking, the coarser the material up to a certain practical size for working, the less capillary saturation and the greater the bearing power. From the figure it is shown there is no exception in the soils but cinders prove to be an exception.

Experiments have shown that a layer of coarse material such as sand or gravel, when placed over clay, retards the capillary water from rising to the top of the subgrade, or in the case of soil roads, to the top of the surface; from which it may be seen that the value of the design of the subgrade not only depends on the regulation of moisture but the selection of the subgrade material as well.

Any system of drainage that will prevent water from finding its way to the subgrade will also serve as a means of freeing the subgrade of the water that does by chance find its way to it. Generally this is found in

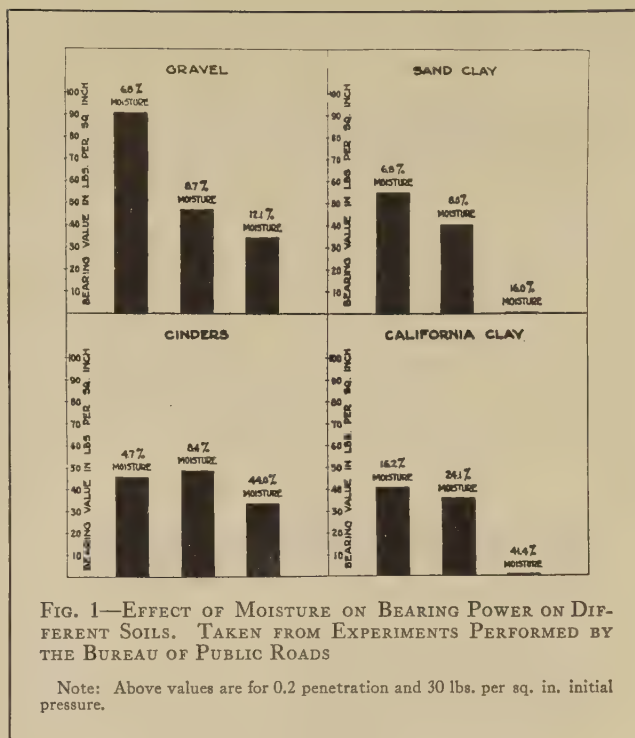


FIG. 1—EFFECT OF MOISTURE ON BEARING POWER ON DIFFERENT SOILS. TAKEN FROM EXPERIMENTS PERFORMED BY THE BUREAU OF PUBLIC ROADS

Note: Above values are for 0.2 penetration and 30 lbs. per sq. in. initial pressure.

the selection of subgrade material and a combination of ditches and underdrains. Care should be taken that the ditches are only of a sufficient depth to lower the water table and are located far enough from the traveled way to interpose no hazard to traffic.

If side or longitudinal ditches are designed properly it seldom happens that longitudinal pipe underdrains are necessary, for the open side ditch will perform all the drainage functions of such drains.

PIPE DRAINS

Oftentimes these longitudinal pipe underdrains are constructed beneath the roadway surface, but it is better to construct the pipe drain outside, for then it can be repaired if necessary without disturbing the road surface. Should pools of water accumulate due to sagging of drain pipe line or should it become clogged, the stability of the subgrade in the immediate vicinity would be greatly reduced. This condition occurring in a pipe line placed under the road surface would reduce the supporting value of the subgrade to the surface slab.

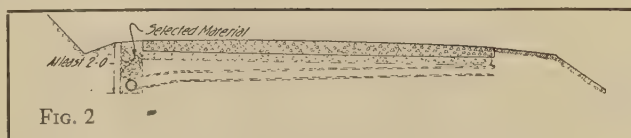
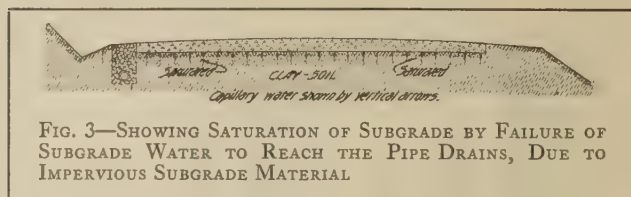


FIG. 2

Lateral pipe drains placed at angles with the longitudinal ditch or pipe drains are sometimes necessary to take care of springs, saturated soil or other sources of water. The number of such lateral drains depends on the nature of the soil drained; the character of the subgrade material largely controls their number and location. The more impervious the soil the greater the number of drains necessary to drain the subgrade.

In certain soils, pipe underdrains are practically valueless, as the rate of flow through the impervious material is so slow that the water does not find its way quickly to the pipe and thus keeps the subgrade saturated and of a low bearing value. In other soils through which water will more quickly drain, pipe underdrains are more effective, and as the soil becomes more drainable the subgrade becomes more responsive

to the use of underdrains, but the necessity of underdrains becomes less.



In impervious soil, pipe underdrains drain only the soil in their immediate vicinity. The impervious soil prevents percolation of water from the under surface of the roadway to the pipe. Soil underlying the surface slab, being saturated, its bearing value is consequently reduced to a minimum.

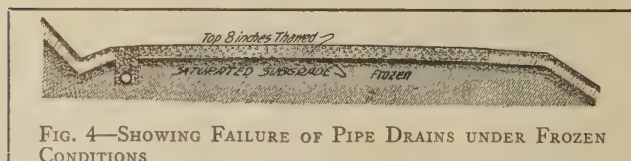


FIG. 4—SHOWING FAILURE OF PIPE DRAINS UNDER FROZEN CONDITIONS

Subgrade and drains frozen below 8 inches. Top of ground thawed. Road surface resting on saturated subgrade of low bearing value. Passage of water through frozen material very slow. Water resulting from thaw being taken care of by surface drains. This figure also shows necessity of layer of pervious material of high bearing value under road slab to support slab while these conditions exist.

Most typical road sections carry a side ditch, the bottom of which is below the top of the subgrade. This ditch is sometimes replaced by a drain, but in either event the purpose is to cut off or intercept any water from reaching the subgrade, as well as to act as a drain or sewer to carry off the water. The side ditch also serves as a connection or sewer to carry off any water from the lateral drains.

The question of choosing between open side ditches or pipe underdrains for the disposal of water is one of service and cost combined. It is both difficult and costly to keep the open ditches free from obstruction of ice or earth slides and in a condition to function all the time. Whether it is more economical to install pipe drains or run the risk of soaking the subgrade and greatly impairing the road improvement is a problem to be met with sound judgment, giving weight to the value of constant service and cost of maintenance, as well as to safety in the operation of traffic.

Hard surface roads practically waterproof or protect from rain the subgrade below the surface. Selected soil roads approach this condition, though in a lesser degree. This is especially true if the water running off the road surface over the shoulder is drained away from the subgrade toward the ditch. Thus we see that the road surface and side ditches protect the subgrade from water from the top and sides but it is not protected from capillary moisture from the bottom which in many soils exists in quantities sufficient to greatly decrease their bearing power and thus weaken the subgrade. It is very difficult to cope with the water rising by capillarity and many times this causes failure of the road surface.

Underdrains in most soils will relieve the ground of free water, but recent research in this field by the University of North Carolina and the State Highway Commission have shown conclusively that underdrains will not take care of capillary water. The ditches and underdrains may be designed to adequately cope with the surface water and water from springs and other sources, yet capillary water may be present in sufficient

quantity to decrease the stability of the subgrade to such extent that it must be cared for.

Assuming that surface water may be cared for by ditches, and that water in the subgrade from springs and other sources may be relieved by underdrains and ditches, the problem of caring for capillary water still remains. The most satisfactory way to cut off capillary water is to introduce a layer of material of low capillary value, or, in other words, a material through which the passage of the capillary water will be retarded. This can often be accomplished by selecting in the grading of the road, material of low capillarity and using it for a subgrade on which will rest the hard surface, or in the case of soil roads, that portion used by traffic. It often happens that it is more economical to borrow material, the bearing value of which is least affected by water, for the subgrade, and it sometimes may be desirable to waste materials from cuts, and borrow satisfactory material for the fills. Too much stress has been laid on the balancing of quantities and too little stress has been laid on the selecting of material entering the subgrade.

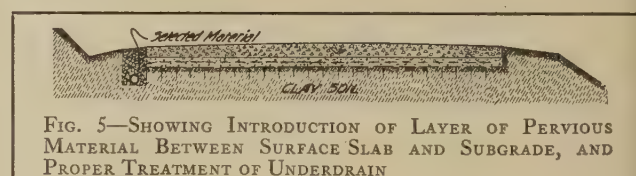


FIG. 5—SHOWING INTRODUCTION OF LAYER OF PERVIOUS MATERIAL BETWEEN SURFACE SLAB AND SUBGRADE, AND PROPER TREATMENT OF UNDERDRAIN

Showing water being intercepted and carried to drainage system by layer of pervious material of low capillarity, and high bearing value assuring better support of the surface slab.

Much experimentation is now being carried on to find a method of changing subgrade materials of high capillarity and of low bearing value into materials of low capillarity and high bearing value. Treatments of clay with tars, lime and other ingredients are being tried, but it is safe to say that no method to date has proved as economical and sure as replacing high capillarity and low bearing subgrade material with another material of known lower capillarity and higher bearing power. The construction of this type of subgrade may seem costly, but when it is considered that the increased bearing power of the soil will, with less expensive surface, carry heavier loads, or with the same surface will last much longer, it can be seen that there is an economic balance in favor of the properly designed subgrade.

In the construction of a road system, it is possible in many cases to build a progressive type road, which is another way of stabilizing successive subgrades and eventually arriving at the hard surface pavement.

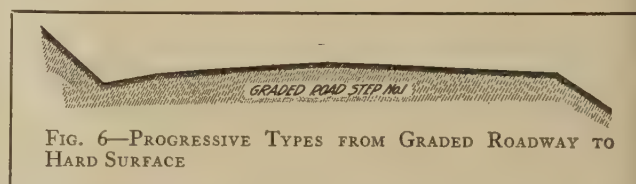


FIG. 6—PROGRESSIVE TYPES FROM GRADED ROADWAY TO HARD SURFACE

The graded road, step No. 1, shows first step in subgrade highway construction and is maintained as such until settlement is complete, or until increased traffic and high cost of maintenance indicate the necessity of the next higher type.

The nature of the soil should determine the character and extent of the drainage system. With a drainable pervious material one system might prove adequate, whereas the same system in an impervious soil would be absolutely worthless.

The selected soil road, step No. 2, shows surface

covered with selected soil, such as sand clay, topsoil or gravel, thus stabilizing the surface and providing material of higher bearing value. This surface is then maintained as a subgrade highway until maintenance becomes heavy or traffic demands a hard surface road.



The hard surface road, step No. 3, is the final step, the ultimate road. The hard surface is so placed that the selected material of the underlying selected soil road which has been serving as a subgrade highway, now becomes a subgrade stabilizer for the hard surface road, greatly increasing its bearing power and assuring an adequate subgrade.



In the progressive type of road all steps taken in its construction include the utilization of the previous construction in transforming to the next higher type, and each step may be considered as a subgrade for the next type. This often justifies the expenditure of sufficient money to select soils of a character that may, with proper maintenance, be used as a surface material until such a time as the traffic demands or the cost of maintenance makes it necessary to construct the next higher type. These selected soil roads may be called *subgrade highways*, and many times are the economic solution for road construction for a large portion of a State system. The selected material on these subgrade highways may be natural or artificial sand clay, topsoil, gravel or a selected earth.

In establishing the grade of a road it is necessary to know the character of the various materials in order that the most suitable material may be selected for the subgrade. Many times it is more economical to raise the grade in the cuts and take advantage of the better material near the surface, and borrow material of high bearing value for the remainder of the embankment, than to balance the quantities by using the material from the cuts if it be of low bearing power. The engineer who attempts to balance quantities, disregarding the quality of the material entering the subgrade, will greatly reduce the strength and life of the road surface and its value to the public.

It cannot be said that the details of ideal design of subgrades up to this time have entered into the details of road construction, with the possible exception of drains, or where by chance the grading of the road supplied the better material. There are many elementary principles that have been established which are not being generally followed.

It is difficult to measure in dollars the value of a properly designed subgrade, for in many instances the surface has borne the blame for failures or received the credit for its success, when in truth, the subgrade was responsible for the condition of the highway. It can be safely said that a dollar spent for the first two elementary principles of subgrade design will return bigger dividends than money spent in any other place in road construction.

Concrete for Sewers

About every so often, sometimes in one place, again another, there is developed a wide-open controversy as to the respective merits of concrete and clay pipe for sewers. Following are six telegrams, all dated in March, 1923, addressed to W. S. Craven, city engineer, Ogden, Utah. They are being circulated by the American Concrete Pipe Association to off-set some recent efforts to discredit concrete pipe as a sewer material.

Replying your telegram regarding use of cement concrete pipe for sanitary sewer laterals be advised same have been used in Los Angeles for several years with satisfaction when same met our specifications. Copy mailed you.

John A. Griffin, City Engineer, Los Angeles, Calif.

* * *

We do not recommend concrete pipe over clay or vice versa. Both have given satisfactory service when properly made and placed.

Bureau of Standards, Washington, D. C.

* * *

Both vitrified clay and concrete pipe sewers are extensively in use in this city and have been for many years. Both kinds of pipe where properly made have given entire satisfaction.

Sylvester Q. Cannon, Salt Lake City, Utah

* * *

Kansas City has had equal satisfaction with both concrete and clay pipe sewers.

Robert W. Wadell, City Engineer, Kansas City, Mo.

* * *

New York City allows competitive bidding on pipe twenty four inches and larger for storm and sanitary sewers. Careful inspection of materials and manufacture essential.

Arthur S. Tuttle, Chief Engineer, New York, N. Y.

* * *

165 miles concrete pipe from 6 inches to 24 inches laid in this city since 1909 for combined sanitary and storm sewers concrete pipe is giving good satisfaction and is being accepted at the present time on an equal basis with vitrified pipe.

O. Laurgaard, City Engineer, Portland, Ore.

Following is a letter, May 2, 1923, by Andrew F. Macallum, Commissioner of Works, Ottawa, Canada, addressed to the secretary of the American Concrete Pipe Association in response to a recent inquiry:

With reference to a controversy conducted here between myself and the Vitrified Clay Pipe Publicity Bureau, I have investigated carefully the relative merits so far as Eastern Canada is concerned, and obtained the following information.

1. Concrete Pipe is not an experiment. It was used in the United States eighty-five years ago, being imported from Scotland. It was so high in cost that after a few years clay pipe was substituted for the smaller sized sewers. Several cities, however, have concrete pipe laid from fifty to eighty years ago.
2. Brick was used in the larger sewers until the price of cement had lowered sufficiently to use concrete, and unless in cases of tunnelling where it is difficult to use concrete pipe, brick is seldom used today. Yet this same agitation was started by the same people in favor of brick about 15 years ago, using the same arguments and statements that they are today using in connection with smaller sized concrete pipe.
3. For obvious reasons the clay pipe people do not question the strength of concrete pipe, but base all their arguments on supposed acids in sewerage. It might be said right here that sewage flowing in sewers in any city is not septic and putrefaction does not take place until it reaches the disposal works or outlets. Yet these disposal works are all made of concrete and no failures have been recorded in this country. E. S. Rankin, of Newark, N. J., Sewer Engineer there for a number of years, carried out probably more research work in connection with sewers and sewage than any other engineer in this country, made the following test about 15 years ago. He placed concrete briquettes in (1) pure water (2) where concentrated sewage from domestic uses was heavy (3) in a factory district where there was a large amount of trade waste (4) in a factory district where most of the sewage came from tanneries and these briquettes were left there for six months and then tested. Strangely enough the three sets that were placed in sewage broke at a higher rate than the set left in water.
4. It may be taken for granted that there are no acids in comparatively fresh sewage in this city to disintegrate concrete pipe made to the specifications now used by the American Society of Testing Materials, when properly cured and tested regardless of the absurd statements made by the clay pipe people.
5. Concrete pipe was easily made by small plants in a careless manner, and for this reason engineers have become prejudiced against it until recently, when first class concrete pipe has been placed on the market by reliable concerns. Upon accepting in this City, it cut prices of clay pipe 30%.
6. I will now pay my respects to the Clay Pipe people and some of their claims. In deep trenches (over 12 feet) I have found numerous broken or cracked pipe, unless the pipe was well bedded in concrete. On the other hand in shallow trenches I find it will not stand the shocks transmitted to it from rapid moving or heavy

trucks. Railroads no longer use it for this reason. Explosions near a clay pipe line are apt to break it and I may say this happened in this city, when sewage from broken clay pipe got into the Aqueduct and the city water supply.

And here is a copy of a letter from William H. Tolles, highway commissioner, Board of Public Works, Nashua, N. H., addressed to the secretary of the Concrete Pipe Association.

This recent testimony is offered here for pipe manufacturers who may have to meet the attack of a competitive material.

Concrete sewer pipe in service fifty-four years was unearthed in

good condition on West Pearl Street, September 6, 1922, as they were razing the old Tremont House.

According to plans and profiles in City Hall, this sewer was constructed in 1868, and was manufactured here by the old natural cement process with tongue and groove joints.

Some of these pipes are on as high as eight per cent grade and rendering excellent service for storm and sanitary sewers, without any sign of erosion, scour or disintegration.

As it is our policy to add a few stretches of concrete pavements each year, we frequently make careful investigation of these sewers which are made in sizes from 8 to 24 inches, and although they are not to be compared in strength and workmanship to the modern concrete pipe, they will undoubtedly give service for a long time.

Some Recent British Concrete Bridges

By MAJOR JOHNSTONE-TAYLOR

Comparatively speaking, there is little highway bridge work carried out in Britain nowadays, but on account of road construction having been neglected during the war period, the work involved in making good the main roads of the country has necessitated the renewal of some of the older bridges.

Among the most recent may be cited the two-arched bridge constructed over the River Trent at Newark to carry the Great North Road. This is one of the most important roads in the country and the bridge in question has to carry the very heaviest road traffic, such as 6-ton steam wagons. The steam wagon, it might be noted, is in use in large numbers; several are designed for loads of 6 tons and speeds of 25 miles per hour.

The bridge in question is a two-arch structure, each of 100-ft. span and a rise of $9\frac{1}{2}$ ft., the total width between the parapets being 40 ft.—that is a roadway of 28 ft. and two footways of 6 ft. Both abutments and the center pier are of mass concrete. The spans consist of four arched ribs. The two outer ones have a section of 3 ft. x 2 ft. at the spring line and $2\frac{1}{2}$ ft. x 2 ft. at the crown. The reinforcement consists of sixteen $1\frac{3}{8}$ -in. diameter rods at the springing which are diminished in number to 8 at the crown. The two inside ribs are 3 ft. square at the spring line diminished to 3 ft. x $2\frac{1}{2}$ ft. at the crown, the reinforcement in this case consisting of twenty-four $1\frac{7}{8}$ -in. diameter rods at the spring line diminished to 8 similar rods at the crown. In both cases half the metal is disposed at the top and half at the bottom, the two sets being tied by $\frac{1}{2}$ -in. diameter rods. The metal work is therefore of the simplest possible description.

Above each rib and connected to it are spandrel columns and a longitudinal main beam, with secondary beams to carry the floor, the whole being in monolithic construction. The bridge, which is designed to carry a moving load of 60 tons spread over four axles, was recently completed at a cost of over £50,000.

BOWSTRING GIRDERS

A structure of interest involving the above form of construction is the street viaduct at Dover. Spans of this type form two sections over railroads. The general arrangement is shown in Fig. 1. Each girder consists of six open panels, the end ones being filled in with reinforced concrete.

The depth at center is 26 ft. 3 in. from the top to underside of bottom boom. The latter is 4 ft. deep by 1 ft. wide and it is reinforced top and bottom by four $1\frac{1}{2}$ -in. bars. The curved top boom is 21 in. x 12 in. in section the maximum reinforcement at center being

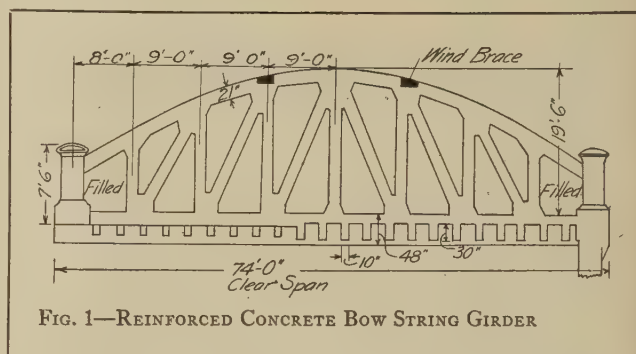


FIG. 1—REINFORCED CONCRETE BOW STRING GIRDER

also four $1\frac{1}{2}$ -in. bars top and bottom. The diagonals and verticals are all of the same section, that is 18 in. x 12 in. and the former have all four $\frac{7}{8}$ -in. bars one at each corner tied every 6 in. by $\frac{3}{16}$ -in. links. In the latter the reinforcement varies. The center one has four $1\frac{1}{8}$ -in. bars and the two adjacent ones four $1\frac{1}{4}$ -in. bars with $\frac{3}{16}$ -in. links at 6-in. centers.

The other uprights have six bars, four being disposed at the corners and two midway between, the corner bars being $1\frac{1}{2}$ in. diameter and the other two $1\frac{1}{8}$ -in. diameter, the tie links being the same as in the other part of the work, including the top boom.

These top booms in turn are connected by two cross beams acting as wind bracing. They are of quadrilateral section 24 in. wide x 15 in. deep on one side and 9 in. deep on the other.

Four $\frac{7}{8}$ -in. corner bars are used as reinforcement, tied as before. The girders are placed at 31-ft. centers

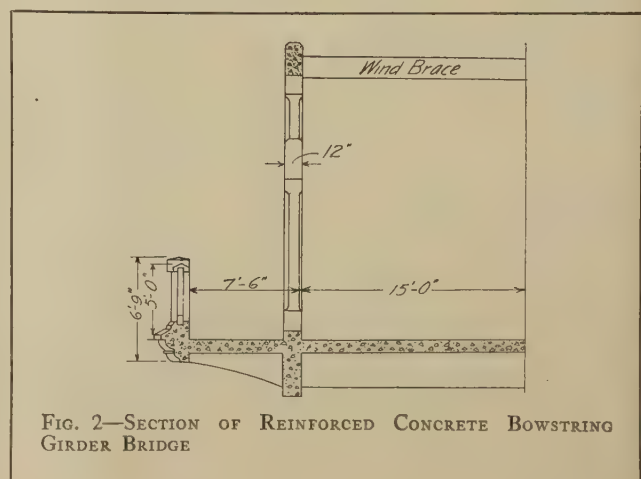


FIG. 2—SECTION OF REINFORCED CONCRETE BOWSTRING GIRDER BRIDGE

and carry the road in between, the two 7-ft. footways being carried on cantilevers outside. The arrangement is shown in Fig. 2.

The main beams carrying the road are 10 in. wide x 30 in. deep, the maximum reinforcement being six 1-in. bars top and bottom with the usual U stirrup reinforcement. The flooring, which is 6 in. thick, is reinforced by 1/4-in. bars at 6-in. centers at the top and 7/16-in. bars similarly disposed at the bottom.

The spans were tested to a maximum rolling load of 96 tons.

A RECONSTRUCTION JOB IN THE LONDON AREA

The work referred to here is a road bridge over a five-track railroad, and it replaces an old structure of the cast iron girder jack arch type, the safe load on which was limited to 5 tons, with, moreover, an inadequate width of only 30 ft. between parapets. The new bridge has a width of 50 ft. between parapets designed for a rolling load of 50 tons on four wheels and a superload of 112 lbs. per sq. ft. on the footways. The old abutments, extended, are in use but the two original lines of cast iron columns have been replaced by one line of reinforced concrete columns.

The design of the bridge includes partly precast reinforced concrete beams and partly "in situ" reinforced concrete beams, the total length between faces of abutments being 97 ft. Columns 18 in. square rise from bases 6 ft. 9 in. square. The outer columns have monolithic connection with the main beams, of

placed between the decking slabs. The latter rest on the sides of the tee head and are 3 ft. 10 in. wide. The beams being placed 5 ft. center to center, this leaves the concrete filling between them 14 in. wide.

The general arrangement of the structure is shown in Fig. 4.

TESTS

As before stated this bridge is designed for a rolling load of 50 tons on four wheels plus 112 lbs. per sq. ft. on the footways.

The official test consisted of the following rolling load:

One steam roller.....	weight 11.75 tons
One steam roller.....	weight 13.75 tons
One petrol roller.....	weight 8.80 tons
Two loaded wagons.....	weight 24.00 tons
One loaded wagon.....	weight 14.5 tons
One loaded wagon.....	weight 11.05 tons
Total 83.85 tons	

Deflection was taken by deflectometers, and under the total load the maximum deflection in the center beam amounted to 0.054 in. or just under 1/16 in., the permanent set after the load had been run off being 0.014 in. Under a load introduced by running all the test vehicles over the bridge, the rollers in line one way and the wagons in line the other way, a maximum deflection of 0.023 in. was recorded. The permissible deflection allowed by the specification was 1/600 of span or 0.75 in.

The final covering of the concrete slabs to form the roadway is mass concrete cambered 1:60, this being finally covered with a 2-in. asphalt and fine granite mixture.

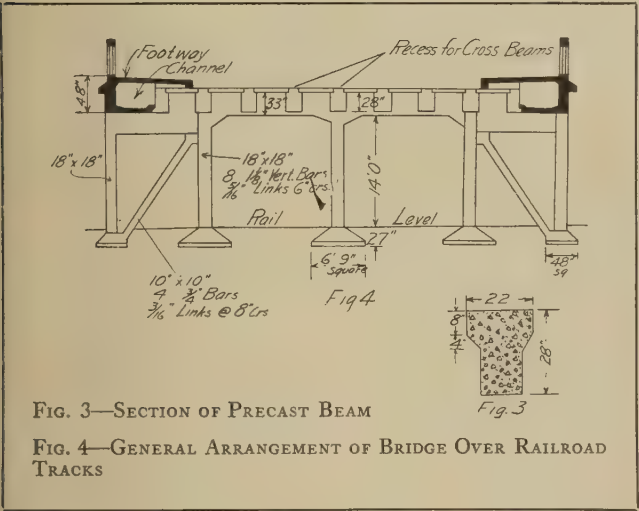
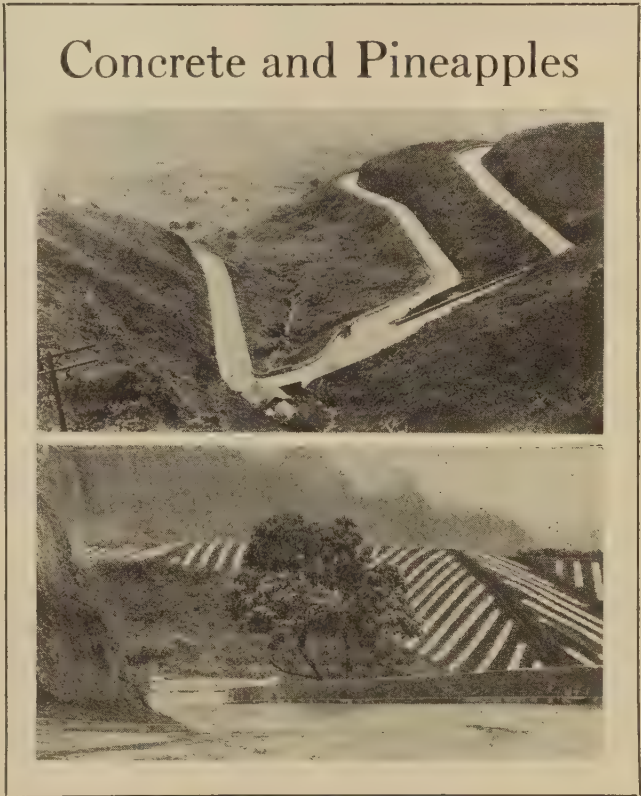


FIG. 3—SECTION OF PRECAST BEAM

FIG. 4—GENERAL ARRANGEMENT OF BRIDGE OVER RAILROAD TRACKS

which there are four, extending from side to side of the bridge and molded in situ. The two outer ones are 16 in. x 36 in. in section and the two inner ones 16 in. x 33 in. These beams are constructed with the necessary recesses for the reception of precast longitudinal beams which extend between the abutment walls at each end and the line of girders in the center of the bridge. Between the two outer columns and those next to them are diagonal bracings. Along each side of the bridge there are continuous reinforced concrete beams 14 in. wide x 48 in. deep, supported by the abutment walls and the outer columns, the latter being in monolithic concrete with them. These beams are extended upwards forming panelled parapets.

The precast beams were made a little distance away and placed in position by a travelling crane. They are shown in section in Fig. 3, being 28 in. deep with a tee head, the maximum reinforcement being three 1 1/2-in. straight bars and three 1-in. curved bars and generally 3/8-in. stirrups. The stirrups, together with the curved bars, were left extended for connection with the concrete



This is truly a "fork" of the Kamehameha Highway, Oahu, Hawaii. It is of concrete with transverse corrugations and a solid concrete guard rail or wall for considerable distances. This is in the pineapple country. The second picture gives a closeup of the pineapple fields. Furthermore it is raining in the mountains.

Heavy Haulage in Highway Construction

By CHARLES H. FRY

PRESIDENT, CHARLES H. FRY CONSTRUCTION CO., ERIE, PA.

From paper presented at Convention of American Roadbuilders Association.

The title of this paper implies a certain amount of foregone conclusion in regard to preference for heavy duty trucks for haulage purposes in connection with highway construction, particularly when presented by an author whose experience has led him into favoritism for this type of hauling equipment. Notwithstanding, this paper is presented with a full understanding that experienced and well informed minds often differ on the subject of methods.

Regardless of the methods employed, several standard methods having gained preference among various highway constructors in various sections of the country, we are, however, allowed to assume that the road constructors and the equipment manufacturers and distributors are all determined upon one definite objective, i.e., production progress with the least waste, i.e., waste capital (investment) waste labor, waste material, waste efficiency, waste what not.

In the last analysis, we aim for the minimum cost per unit of laid concrete, excavated or filled earth or rock.

The proposition which concerns the members of this audience, in their everyday experience with the trade, is what method attains the common objective and proves itself superior over all other methods? This is a question not easily answered.

DETERMINING FACTORS

VARIETY OF ROADS

The natural sand-gravel roads such as abound on and near those flat plateaus surrounding and adjacent to the Great Lakes, as well as similar natural roads found in other sections of our country, also the rock formation forming the sub-base for so many of the roads in the mountainous districts of the United States, without a doubt, serve best for permitting the utilization of the heavy duty truck. This type of sub-base permits the early escape of water from rainfall and consequently discourages lay-up of heavy duty trucks at times when saturated clay and muddy roads would necessitate costly loss of time from interrupted operation. Such a factor has contributed toward making the author a heavy duty truck enthusiast when possibly a highway contractor in some other section of the country would favor a different method.

One point to consider in this connection is—in how large an area of our country can the heavy truck be utilized to advantage? The factors to be considered in this paper point the way to a comprehensive survey. Recent charts compiled and edited by the Associated General Contractors of America, showing the seasons of the year adapted and in use for road construction purposes in the various States of the Union, will serve as a guide in reaching a conclusion.

HAULS

Closely related to the foregoing and hardly less important is the subject of hauls. Obviously the only ones to be considered are short and long hauls. Other things being equal, the advantage is constantly growing in favor of heavy duty trucks because of the increasing tendency toward longer hauls on contracts being let by State highway departments.

The long haul utilizing heavy trucks reduces the amount of field supervision required when fleets of small trucks are on the road. In operating fewer units they are less likely to get in one another's way. Simple though it may seem, this is a very important consideration in the hills and in the mountainous country removed from the Lake Region and the flat country of the Middle West. The long haul manifests the advisability of heavy units, particularly when taking into consideration the availability of experienced and dependable labor.

COORDINATION

We cannot intelligently discuss haulage characteristics and requirements without taking fully under advisement the correlated equipment and special appliances which are utilized in the other operations. Of late years road construction has been aided by many improved types of equipment. The equipment manufacturers have been practical students of a stupendous industry.

Gliding into position under an improved and latest design measuring and striking off hopper, a heavy duty truck stops for the fractional part of a minute, swallows its load of four standard six bag batches of aggregate and is off in no more time than is required to do the same thing with one batch only on a light truck.

And when the big truck arrives at its destination, backing into the paver, the fewer the trucks, the less the disturbance along the way and at the paver itself.

MAINTENANCE

Without entering into an analysis of pure cost data or summarizing along this particular vein, there are outstanding merits in favor of heavy trucks along lines of pure operation and maintenance.

Restricted labor supply warrants the conclusion, comparatively speaking, that a few dependable and seasoned truck drivers of known qualifications form an operating force far superior to a larger force of doubtful personnel.

The trained driver on the big truck, educated to maintain his unit and to take pride in its performance is an asset to your organization and a factor to be considered in getting the unit of pavement laid at the minimum of cost. The maxim is efficient drivers and maintenance men, and they are ordinarily few, particularly when labor is at a premium.

In this connection, it is known that heavy trucks are slower than light trucks, nevertheless, there is apparently an advantage in wear and tear. It appears that the heavy truck stands the vicissitudes of operation to more marked advantage—the ruddy frames, the heavy wheels, the big tires, the staunch bodies, as well as the enlarged members of motor, driving and transmission machinery, the ability to take punishment, seem to stand the gaff and afford satisfactory overhaul.

FLEXIBILITY

The expenditure for any type of hauling equipment is the largest item of the contractors plant. This fact alone should cause the contractor to choose the most flexible equipment. He will be forced from time to time into competitive bidding upon all kinds of road contracts. Heavy duty trucks provide for this flexibility.

Heavy trucks require less space during lay-up. They represent an advantage in towing other types of equipment. They increase the facility with which the general equipment is moved on and off the job. The heavy unit will pull up and take any grade that the light unit can negotiate.

The greatest argument against heavy trucks seems to have been accusation that the sub-base was subject

to an excessive amount of cutting up; but experience substantiates the contention that when sub-base conditions are at all favorable, the big trucks with their wide tires iron out the sub-base and pack it down like a roller.

Foster Unit Slab System

In line with the endeavor to standardize units of design in building and other construction and in an effort to meet the high cost of labor and material, a system of construction has been invented by the Foster Engineering Service Co., Indianapolis, Ind., which enables the company to build in standard units.

The method of procedure is to design in units. Every building in which the company assists in the design, is made to fit these units and it is claimed that this system takes from 10% to 40% less material. There is no fabrication of steel. The concrete is placed mechanically by the company, materials and labor furnished at 50c per hr. The forms are built, concrete

poured and finished at the rate of \$20.00 per cu. yd. for reinforced concrete. The buildings are absolutely fireproof and are built in competition with mill construction and steel framing.

The accompanying sketches will give an idea of the system and its flexibility. Two applications are shown in the sketches, the one marked "A" is considered by the designers to be most economical and ideal as regards both cost and service.

It will be noted that type "A" requires only a 4-in. slab over the unit for a 450-lb. live load. Types "C" and "D" require a 5-in. slab for the same loading. It is recommended by the designers that the building plans should be made to fit some regular type unit with as little flat slab construction as possible.

Units are octagonal in shape with a dip in the center toward the column from 6 in. to 18 in. and the units are made in three sizes: 18 ft., 24 ft. and 30 ft. A unit figured as a cantilever umbrella over a single column, which transfers the load in a straight line direct to the column and in this way removes the dead weight at the center of the spans, makes a great saving in the material.

The word "unit" implies a single column instead of four, and it is cited by the designers of the system that

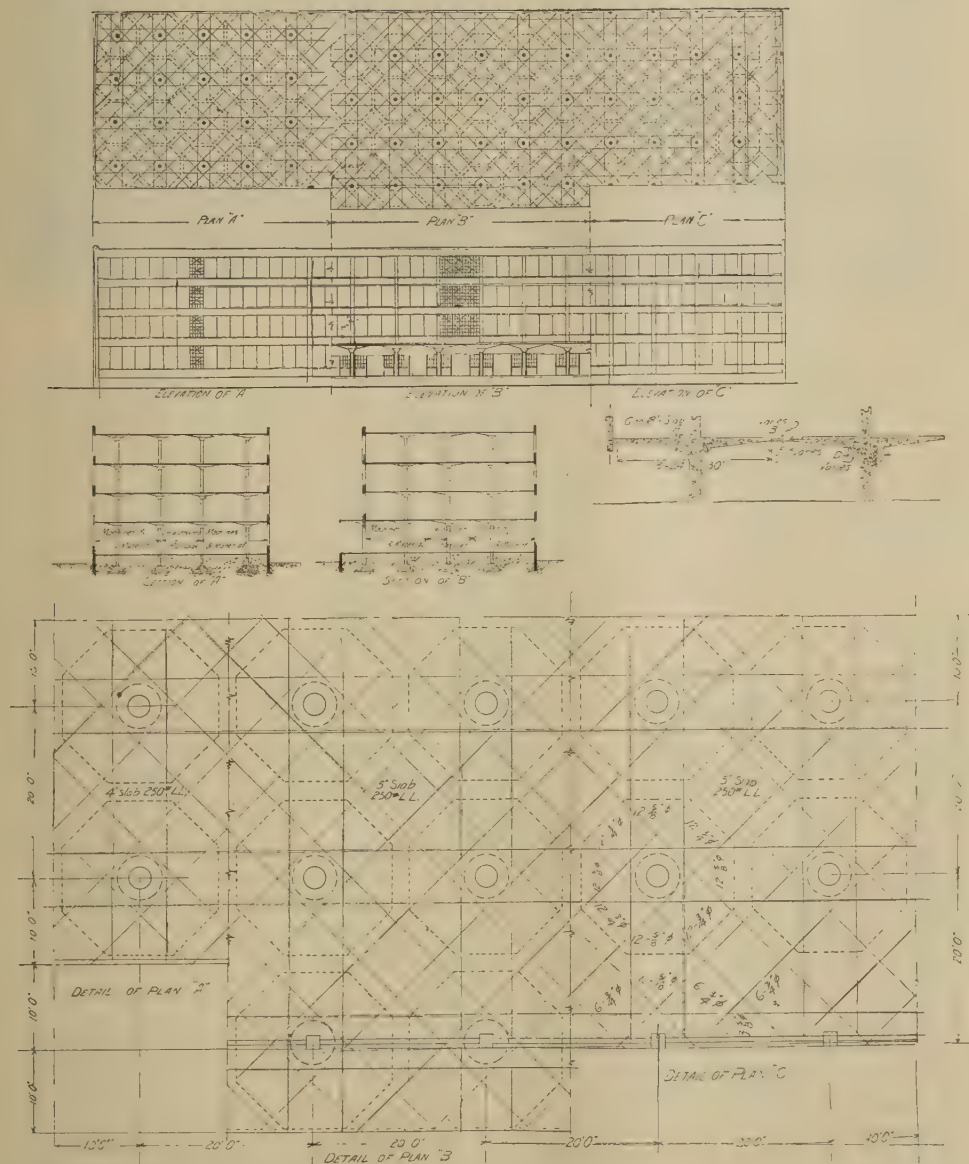


FIG. 1—PLAN, ELEVATION AND DETAILS OF FOSTER UNIT SLAB SYSTEM

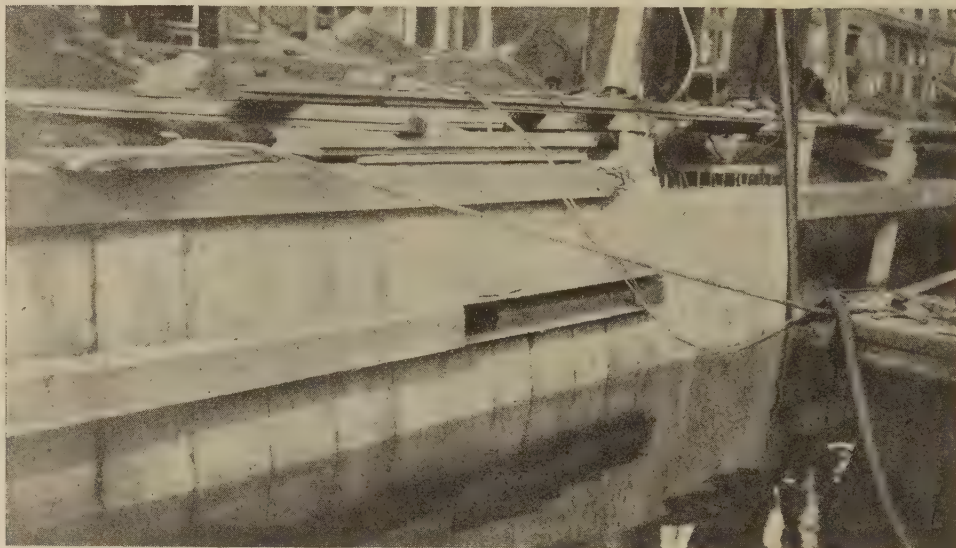
an outside unit is as strong as any other. When the single unit is once designed, the building is constructed with a multiple of such units. The unit most economical for the span desired is first selected and the building constructed from the basement to the roof using the same unit base. The thickness of the top slab is varied and the steel varied to meet the different load conditions. The same forms are used for a roof load of 30 lb. per sq. ft. that are used for a 300 lb. per sq. ft. live load.

Several large buildings have already been built using this unit system and other buildings are under construction, one with a 37-ft. span without a girder. The accompanying illustrations are from sketches for the checking of the engineers of the General Motors

Co., at Flint, Mich.

The work of the Foster Engineering Service Co. to which we are indebted for the foregoing information, parallels to a certain extent an investigation made by a committee of the American Concrete Institute in the matter of the standardization of units in reinforced concrete building construction, with a view to economy in forms and other factors. The special committee after studying the question of standardizing construction made recommendations for footings, columns, beams and girders, story heights and steel reinforcement. The report of the committee with a summary of its findings was published in CONCRETE for March, 1920.

FIG. 1 — REVETMENT UNDER CONSTRUCTION, USING REINFORCED CONCRETE SHEET PILING



Reinforced Concrete Boards for Canal Revetments

LETTERS FROM HOLLAND

BY HENRY J. HARMS

The Hague is a city with less canals than Amsterdam, the "Venice of the North," as every good Amsterdammer proudly recalls a saying of some artistically inclined traveller, but the Hague, like every good Dutch city, has its "grachten" and "singels." Both are canals, traversing the city, but the "singel" used to be a water route encircling the town. Most of these canals were, in early times, green-bordered affairs; but ever-increasing traffic necessitated widening of the roadway and encroaching upon the grass border, as moving back the houses would have been too costly. So, slowly but surely, the nice green borders disappeared, the canal sides became straight, and usually a timber revetment was used. This wooden construction, however, proved to be an expensive one, on account of upkeep. It would last from 10 to 15 years, and if not kept in good repair, constantly, it soon became a shabby looking, although picturesque, eyesore.

Now, the Hague is one of the cities of Holland where the municipal engineers are live wires, full of pep,

anxious to modernize the city, of which they are proud. And when it was decided by the aldermen, after year-long fights and debates, that the wooden revetments should be replaced by something more substantial, the engineers decided to use concrete—this against the example and practice of Amsterdam, where brick is almost exclusively used for this purpose. Various schemes and methods of reinforced concrete revetments were suggested, some of them experimented with, until the engineers have developed a type of revetment which seems an ideal one—simple, practical, easy to place and relatively cheap.

The revetment in question consists of reinforced concrete tongue and grooved boards, a regular sheetpiling as shown in the accompanying illustrations of a length to suit the case. Figs. 1 and 2 are reproductions of photos taken by the writer in September last year. The canal there is about 12 to 15 m. wide, and is used by lighters, barges and motor-barges, going at a moderate speed. Right next to the revetment there is only a little water, 6 in. at the most, but the bottom slopes rapidly towards the middle of the canal. The revetment is about 80 cm. high, the water being kept at almost constant level, summer and winter. The boards used in this case are 3 m. long, thus going a little over 2 m. into the ground. Halfway, the canal is a side-canal, crossed by a bridge about 2.50 m. above the canal. Here, too, the boards go to the same depth in the ground, the only difference being that one longitudinal rod is added to the reinforcement and that another row of anchors is added, going to the top of the piles.



FIG. 2—JETTING DOWN SHEET PILING

The sheetpiling is jetted down, as shown in Fig. 2. A rotary pump is used, placed on a barge lying just behind the lighter with the ready-made boards. Power is electricity, obtained from the city lines. The pictures show clearly the wooden liners, the top one being at the required level. Once the board is at its required depth, the inside reinforcing rods sticking out above the boards, as shown, are bent over the liner, as is also the loop used for hoisting the board, which is then fastened with a nail to the liner. Further sinking of the board is thus prevented. When sufficient length has been placed, the reinforced concrete capping is placed (see Fig. 3). While jetting the boards, the bottom is kept in place by holding against it a stick, stuck in the ground and held by the man on the lighter.

About every 20 boards, a wedge-shaped board is used to adjust vertical deviation of the sheetpiling.

The anchors pass through a channel-iron, placed some distance above the water-level. Once the nuts are tightened up, the rods are sawed off, and a 4-in. x 6-in. waling strip is placed in the channel. The whole equipment consists of a handy 2-legged derrick, guyed to anything handy such as trees, lampposts, sometimes the houses; the pump and the two lighters. A gang of 5 men, 4 on shore and one on the lighter for hooking on the boards, placed regularly 25 to 30 m. of sheetpiling per working day, capping included.

As to the price, the city engineers reported that the work cost the city, everything included, 30 guilders per running meter. The boards are made in the city cement works and transported on lighters. The city also supplies the plant, current, etc., while the work of plac-

ing the revetment is given out at a certain price per meter. All these items together give them the price stated, and it was said to the writer that this is cheaper than a wooden revetment would have been. With almost any other type of revetment, it would have been necessary to use a cofferdam. I must add, that on the work in question, the reinforcement consists of five 9-mm. rods, while the cap reinforcement consisted of two 9-mm. longitudinals. Concrete was 1:2:3, rather coarse gravel being used.

The rotary was a 4-in. pump and the electric motor $\frac{3}{4}$ H.P. The cap was 18 cm. wide and 20 cm. high. Anchors consisted of 19-mm. rods, every three meters, fastened, five meters back, to cast-iron blocks coming from the municipal scrap heap. I was told that generally concrete blocks were used for deadmen, about 75 x 50 x 30 cm. Piles are now rarely used for this purpose, as they must be cut off below water-level, requiring deeper digging and thus increasing the cost. The concrete, as well as the cast-iron deadmen have proved entirely satisfactory.

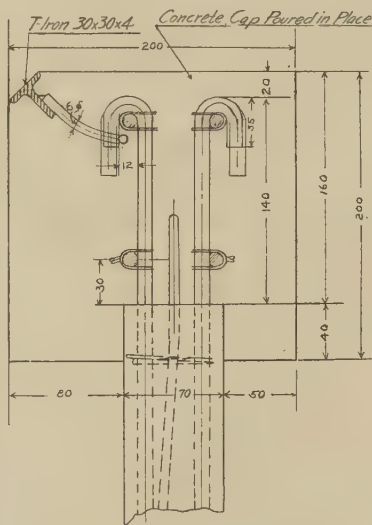
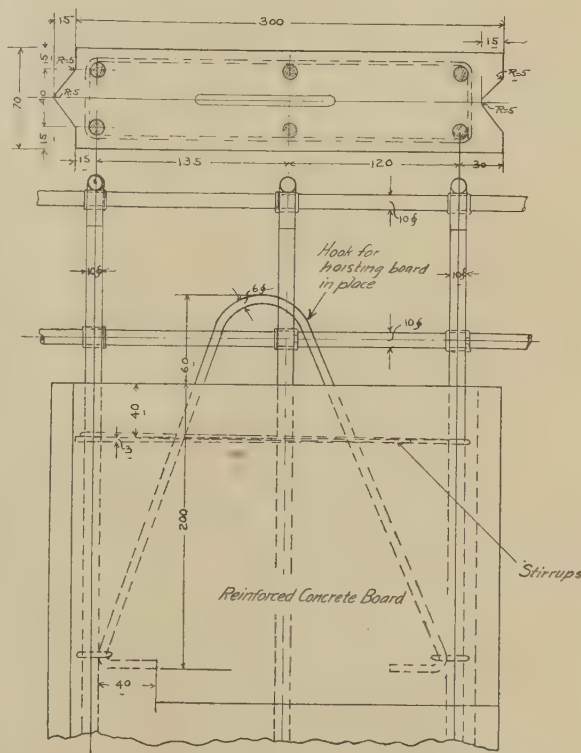


FIG. 3—DETAILS OF
REINFORCING IN CAP
AND BOARDS



Minneapolis Concrete Men Advertise

The Minneapolis *Journal* for Sunday, May 20, has an interesting feature. It covers about two-thirds of page 7 in the Real Estate and Building Section, under the heading, "For Beauty—USE CONCRETE—For Permanence." It shows a perspective and a plan of an attractive dwelling designed for concrete construction, finished with stucco. Under this plan presentation, which has a running story descriptive of the house, are the advertisements of twelve manufacturers of concrete building units and two contractors advertising work on

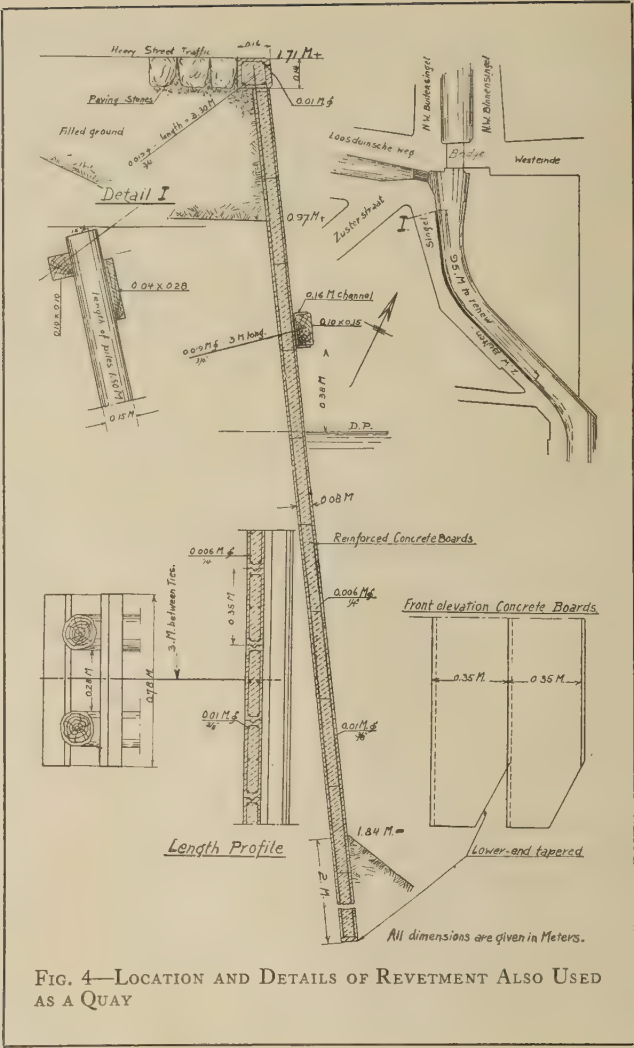


FIG. 4—LOCATION AND DETAILS OF REVETMENT ALSO USED AS A QUAY

The drawing, Fig. 4, shows one of such revetments, built in 1919, at one of the busiest thoroughfares of the city, for a quay the top of which is 1.71 m. above the water-level, while the canal is 1.84 m. deep against the revetment. Against this quay are moored lighters, etc., unloading on the quay and stacking the goods high. Heavy trucking passes close by and the surcharge is therefore considerable. The boards used were 8 cm. thick, but the standard at present, is 7 cm. Anchorage is from top and from channel, to regular pile-deadmen, 3 m. back. It will be clearly seen that conditions are much more severe than in the first case. The depth of water against the boards is considerable, and according to the engineers, there is even more water, as through the churning of the propellers of the lighters, backing against the quay for turning, the ground has been sucked away to a greater depth. Still, the boards extend only 2 m. into the ground. Roughly calculating the boards, I found that, according to theory, the boards should have been much heavier, at least 12 cms., and much more reinforcing should have been used. The channel stringer also should have been very much heavier. I took this question up with the engineers and they admitted that their own calculations gave the same result. But—against these purely theoretical figures, based upon assumptions that still have to be proved, the fact remains, that this particular revetment has stood for 4 years now, without having shown a sign of failure. Repeated observations and check measurements, for deflection, etc., have shown that no movement has occurred.

CONCRETE BLOCKS

1,200 Pound Test Blocks Cost No More Than Inferior Ones.

Manufacturers of Garden Furniture
We Guarantee All of Our Concrete Products
Oldest Concrete Block Manufacturer in the City.

ANCHOR STONE COMPANY
2937 Lyndale Avenue South Minneapolis, Minn.

Better Than the 1200 lb. Test Vapor Steam Cured Concrete Blocks

Made in the largest factory in the Twin Cities
with the finest machinery obtainable.
Our blocks are approved by the building inspector.

John A. Peterson & Son
CONCRETE BLOCKS
Highland and Westmoreland Ave. Walnut 0278

CONCRETE BLOCKS stuccoed make a warmer, drier, more beautiful house. Use them both for beauty and permanence.

Our Products Comply With the Building Inspectors' Requirements

A. L. Anderson
CONCRETE CONTRACTOR
Sidewalks, Foundations, Steps, and all kinds of Concrete Work.
Factory 4227 4th Ave. So. Locust 5677

THREE SAMPLE ADVERTISEMENTS FROM THE MINNEAPOLIS *Journal*

sidewalks, floors and pavements. Some of these ads are 2 in. deep and two columns wide, some of them 2 in. square, and some of them 2 columns wide and only 1 in. deep. The producers who are doing this progressive advertising in Minneapolis are as follows:

Carlson & Johnson, 5925 Pleasant Ave. S.; Ideal Cement Construction Co., Matson Bros., Props., 2912 Lowry Ave. N.; North Minneapolis Sidewalk & Block Co., Albert Nelson, Prop., 2715 Washington Ave. N.; Oscar W. Berg, 3112 N. 2nd St.; Minnesota Cement Construction Co., 803 Hennepin; Minneapolis Paving Co., John L. Beckman, Prop., 67 Penn Ave. N.; Cust. Strom, 3115 29th Ave. S.; Model Cement Stone Co., 2224 E. 36th St.; Munson Stone & Tile Co., 4535 28th Ave. S.; A. L. Anderson, 4227 4th Ave. S.; John A. Peterson & Son, Highland & Westmoreland Ave.; Anchor Stone Company, 2937 Lyndale Ave. S.; Oscar Roberts, 58th St. & Girard S.; Lake Street Sidewalk Co., 2909 26th Ave. S.

We need copies of 1922 Mill Editions of CONCRETE for January, February, March, May and July, and Regular Editions for February and March. For each copy sent us (within 30 days) we will extend subscriptions two months. Two magazines for one. CONCRETE, 1807 East Grand Boulevard, Detroit.

Graded Aggregate:

gathered from the job, the office, the factory, over the lunch table, in Pullman smokers, from the morning mail and many other sources.

News, Review, Hearsay, Comment—
A Department of Fragmentary Miscel-
lanies—the material for which will be

Apprentices and Craftmanship

"Increase the number of apprentices in the building crafts and give recognition to real craftsmanship," was the keynote of remarks made by D. Knickerbacker Boyd at the 56th Annual Convention of the American Institute of Architects in Washington, D. C. It is true that while building itself has greatly increased in the last ten years, excepting the period following the War, the number of workers in the building trades has constantly decreased. The difficulty seems to be, according to Mr. Boyd, simply that boys are not sufficiently interested in the crafts, in achieving something definite and dignified with their hands. It is up to construction groups, the public and architects to remedy this condition. Publicity, and recognition by designers of the artistic and skillful working out of their sometimes vaguely specified creative ideas, are the necessary elements. If the journeyman of the present generation is encouraged and his efforts are appreciated by the architect and public recognition, then he will urge his son and his nephew and the boy next door to train for a craft. What would become of the best of plans without good "workers on the job"? In the book descriptive of materials used in the "model home" built for the Palace of Progress exposition in Philadelphia, recognition was given to the workmen—bricklayers, mortar mixers and hod carriers. In appreciation, the men—who had been working day and night for two weeks—refused pay for overtime or night work: their efforts to please the public were being recognized. Mr. Boyd urged that architects everywhere individually put in the encouraging word that will be another drop in raising the level of the standard of craftsmanship. And to this brief summary of Mr. Boyd's comments it might be added that pride of craft is incompatible with the "stick-it-on-and-slick-it-up" workmanship so common in speculative building enterprises. Pride of craft belongs to that type of building construction which, through characteristics of relative permanence, is likely to be more of a monument to the men who built it.

* * *

CONSIDERING THE DISINTEGRATION OF CEMENT IN SEA WATER, our complacency about present cement standards is given another jolt by William G. Atwood and A. A. Johnson of the committee on Marine Piling Investigation of the National Research Council, in a paper presented in June before the American Society of Civil Engineers. The authors point out that foreign literature indicates clearly that the cause of alteration of cement in concrete is well understood and that several means for overcoming the difficulty have been used with more or less success; while in the United States it appears that *the attempt to make and use a standard cement for all purposes has probably been the cause of many structural failures and in time will cause many more.* The rate of disintegration is affected by many factors, but even if the concrete is mixed and placed in accordance with the best practice,

resulting in a material of maximum density, disintegration takes place although much more slowly than if the porosity is greater. Any increase in permeability increases the area exposed to salt water and consequently hastens the rapidity of disintegration. In northern latitudes the chemical disintegration is accelerated in porous concrete by the action of ice within and without the structure.

* * *

A Jet-Like Special Aggregate

A number of years ago there was available to concrete products manufacturers a special jet black aggregate, angular and sharp, grading from about like rice or smaller down to a very fine material. It was used more or less extensively with lighter material in producing granite-like effects in concrete stone. This was a bagged material sold under a trade name. While we believe it can no longer be obtained through the same channels as of old, it is interesting to know that a similar if not an identical material is available from copper refineries. Inquiries for the material started this magazine on the search for a supply and it was found in what is known as granulated blast furnace slag from copper producers. It is largely a waste material so far as the producers are concerned and if a demand for it is evident, in the concrete field, a supply could undoubtedly be obtained.

The difficulty with the producers is in putting it in proper shape for marketing. Nothing has to be done to the material except to ship it, provided it could be handled in car lots. Bagging it, however, to sell in smaller quantities is a larger undertaking and grading it would involve still greater difficulty, if grading were necessary, in order to deliver it in various sizes. Just as it comes, however, it appears to have a field of usefulness as a special aggregate.

* * *

GIVING THE JOB TO THE LOWEST BIDDER as in many places is legally necessary, doesn't always give the public the best work. This has been noticed in some localities on school work.

* * *

Needs Three Tools

"I do not see," says George H. Martin, Winchendon, Mass., "why some manufacturer does not make some conveniences for conveying concrete from a mixer to forms, for small jobs. I use coal hods on all my light work instead of pails. They are more practical for dumping into narrow forms, as for an 8-in. wall; but they are not durable and are too high. Some one should make a special hod for concrete—low down, squatty, with long spout of sheet iron and with heavy iron bar at bottom and top, for strength and rigidity. Another convenience I have had made to order, to carry cement, is a wheel-less barrow. It has two handles with sheet iron body and spout on each side. Handles

project out on both ends, so two men can carry a small batch.

The idea of this carrier is to have a spout like a coal hod on both sides so as to balance and also dump right and left and get in between 2 x 4 studs. This cement carrier comes in handy on all small jobs where it does not pay to erect a permanent run or carrier—such as odds and ends on a big building. Still another tool is needed to use in concrete walk shaping—a piece of board, say 4 ft. long by 4 in. wide, cut out to form a 1-in. crown in a 4-ft. walk, allowing all water to drain off walks when it rains or thaws. Some concrete machine manufacturer could manufacture a sidewalk shaper of trowel steel, say from 2 ft. 6 in. to 3 ft. 6 in., etc., up to about 6 ft. 6 in. long, with $\frac{1}{2}$ -in. bevel on 2 ft. 6 in. up to 2 in. on 6 ft. 6 in. The broader the walk the deeper the crown.

* * *

MAKING GOOD USE OF WHAT IS AT HAND IS REAL ECONOMY AND CONSERVATION. In addition to the suggested new tools, Mr. Martin has an interesting advertising line on his letter heads—along with a picture of his own home. This is a bungalow kind of place with a facing of small field stone. The ad line is this: Native Masonry a Specialty. *Native*, that's the idea. Let us learn how to use concrete to make it Native to the parts to which it belongs. Let us have houses which instead of adhering to traditions, express certain local characteristics. Concrete is a very obedient material. It provides a means for using what in many places is directly at hand.

* * *

Roof Tile Color Problems

There are several possible solutions of the problem of color in concrete roof tile. There are many concrete tile roofs a dozen years old which still have good strong color. Others show fading after less time than that.

The first requisite is a good quality mineral color not merely so it will not fade but so that less color in the mix will give the desired color in the finished tile. The more color you mix with the cement used in finishing the surface of the tile, the more you weaken the binding quality of the cement. Thus tile which have too high a proportion of color to cement have very little strength in the binder which holds the color in place. Such tile "fade" not necessarily because the color fades but because it is actually washed off the tile surface. This wearing away of the surface goes on slowly but it is not surprising that it happens. Nobody would think of making a facing mix for concrete block or trim stone, of half color and half cement, yet a tile surface is much more exposed to the elements and some manufacturers expect a thin film of color to stay in place indefinitely.

Two steps toward more permanent roof tile color are better mortar color materials and less of them.

Another step will be in the education of the public away from the solid, deep, uncompromising reds and greens to softer and more subdued tones. The use of strong colors is merely imitative, because clay tile are that way. Softer colors are to many people more pleasing. Another step is in the use of mixed colors on the same roof. The best looking concrete tile roof we have ever seen was made that way—a dozen or fifteen different colors, shades and tones intermingled haphazard, with no design. Such roofs make for a more conservative and therefore a more lasting use of colors. If on such a roof some of the colors are not permanent, the result is no hardship.

All this points to a further and more radical step in making concrete roof tile. Why not, by using only

good colors and much smaller percentages of color, mix the color all through the batch—make the tile of one substance and color for their entire thickness? Probably there are roof tile color and texture possibilities in the use of special, colored aggregates. That is something else to think about. These and other things will probably be threshed out in the next few months by a new committee of the American Concrete Institute assigned to roof tile problems.

* * *

TO REDUCE STANDARD CONCRETE BUILDING UNITS TO A FEW STANDARD SIZES instead of the multiplicity of shapes and dimensions which now confuse the would-be user, the Department of Commerce has taken the first step by calling a conference of the interested manufacturers and others.

* * *

Floors That Are Touched by Frost

The best thing for "concrete floors that are touched by frost" is not to let it happen. All through the cold weather the question of what to do, comes at frequent intervals. So now, well in advance of the next cold weather contracts, it is a good idea to plan the job otherwise. It is too much to expect that concrete, especially in the making, will come through somehow with any old kind of treatment.

Don't let the floor be touched by frost. It does not help the builder of a concrete floor which does not turn out right to remind him that Jack Frost is capricious. Nearly every contractor has had at some time or other an experience with frozen concrete which will lead him to have misplaced confidence in the harmlessness of freezing.

He has had frozen concrete which thawed out and became very hard indeed. This concrete may have been in a fairly thick slab or retaining wall. He then expects that an inch or inch and a half thick floor topping will perform in the same way, and great is his disappointment when the topping fails to harden and probably breaks away from the base slab.

Undoubtedly the effect of freezing would be exactly the same if all of the conditions were the same; that is, if the same amount of water were used to gauge the concrete, if the humidity of the air were exactly the same, temperatures identical and if the length of time between freezing and thawing out were the same in all cases, the results would be identical.

The treatment, however, of a wearing course of a concrete floor is different from that of ordinary reinforced or mass concrete. This topping is often placed on the base slab after the latter has hardened, and in addition to the necessity for obtaining a hard, wear-resistant surface, a perfect bond with the slab must also be had. If the floor topping is frozen before it has had an opportunity to harden there is every chance that moisture will be lost from the thin top coat into the old slab prior to the frost reaching the plane of contact between the slab and the topping. Evaporation of moisture from the thin topcoat, of course, goes on to a certain extent during the time when this topping is frozen, and especially when it is only "touched by frost." When the topping is completely thawed out, the moisture will very likely have been lost from it so that continuation of the hardening process cannot be resumed.

The proper method to treat such a floor is, therefore, to supply moisture to it immediately on thawing out. The floor should be heated to a temperature which will permit rapid chemical action between the cement and

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water. Moisture and heat should be supplied continuously to the floor for a period of two or three weeks. If at the end of this time the top surface has become fairly hard (it will not have completely hardened), confidence may be had that a reasonably good surface will finally result. One of various floor hardeners will probably help too to get a better wearing surface. If, however, the floor is soft and dusty, usually the only remedy is to take it off and put on a new topping. In either case the ounce of prevention would have been worth a pound of cure.

* * *

THERE ARE ELEVEN MANUFACTURERS OF CONCRETE BRICK IN PHILADELPHIA with a daily capacity of 300,000 brick. Just a short time ago concrete building units were practically unknown in that city. Even now they are made, sold and used under an adverse building code through special permits. The Philadelphia producers have organized the Philadelphia Concrete Brick Manufacturers Association.

* * *

Test Laboratory Principles on the Job

An extensive series of concrete strength tests on an actual building operation under the combined auspices of the Joint Committee on Concrete and Reinforced Concrete, the Portland Cement Association, the U. S. Bureau of Standards, and a committee representing the contracting industry has just been undertaken. In general the tests are to demonstrate the practicability under job conditions of the principles of concrete mixtures recently evolved in various laboratories.

The tests are to be carried out on an 8-story building operation which Stone & Webster, Inc. has under way for the Victor Talking Machine Co. at Camden, N. J. Delaware river aggregates, common to the Philadelphia market, will be used.

Strict water control will be accomplished by accurate water measurement at the mixer, checked by slump and flow table tests. Numerous 6-in. x 12-in. cylinders (3 every hour of mixing time) will be taken for 28 day, 90 day and 1 yr. breaks, which are designed to show the uniformity of strength obtainable with accurate water control under job conditions.

Another line of investigation requires the cutting of cylinders from actual structural concrete, to demonstrate whether molded specimens correctly represent the actual material in the building. It is also the intention to make several batches of especially designed proportions to test out the latest principles derived from laboratory investigation.

A comparison between field made and laboratory made concrete with identical materials is also to be made, as well as a thorough study of the cements used. The technique of job testing will also receive attention.

W. A. Slater, Engineer Physicist of the Bureau of Standards, is Director of Tests. He will be assisted by Stanton Walker, a concrete technician from the Structural Materials Research Laboratory, Lewis Institute, Chicago, who is in direct charge of the field testing work. Richard L. Humphrey is Chairman of the Joint Committee, and M. J. Whitson of Stone & Webster and M. M. Upson of Raymond Concrete Pile Co. are Joint-Chairmen representing the contracting industry.

* * *

AMERICA'S TENNIS STADIUM, to seat 12,000, designed by Charles Landers, Engineer, New York city, is being built of reinforced concrete at Forest Hills, Long Island, on the grounds of the West Side Tennis Club, by the Foundation Co.

COLONEL D. H. SAWYER HAS BEEN APPOINTED SECRETARY OF THE ASSOCIATED GENERAL CONTRACTORS OF AMERICA to fill the place of Eugene Young who recently resigned to enter business in Minneapolis. Born in Mt. Pulaski, Ill., Colonel Sawyer graduated in engineering from the University of Illinois and is a member of the American Society of Engineers. Engaged in engineering and building operations for about a year he returned to his native state, becoming city engineer of Paris. Later, as chief engineer of the Illinois Traction system, he had charge of the construction of most of the interurban lines of that company which connect the larger towns of Central and Southern Illinois. In 1908 Colonel Sawyer joined his brothers in the Northwest, forming the firm of Sawyer Brothers, who, with offices in Seattle and Spokane, engaged in consulting and designing engineering work, covering fields of municipal improvement, irrigation, drainage and kindred work. He was commissioned a major in the Quartermaster Corps and assigned as Construction Quartermaster to build the original Camp Grant in May, 1917. During remainder of War, Colonel Sawyer was engaged in building a nitrate plant near Cincinnati, Camp Bragg, and in a supervisory capacity was in charge of construction of quartermaster storage projects throughout the East and Central West. Upon resignation from the military service, he became associated with the James Stewart Co. being engaged on various building enterprises.

* * *

SAND MAYBE TESTED FOR PRESENCE OF SILT AS FOLLOWS: Fill a 32-oz. graduated bottle with sand to 14-oz. mark; add water to 28-oz. mark, shake vigorously for one minute and allow to settle for one hour. If more than one ounce of sediment appears above sand, the material represented by the sample should not be used.

* * *

A NEW NON-BRITTLE GLASS WAS CITED in September, 1922, CONCRETE, in an editorial bearing on future developments of better cement. Modern industrial conditions as well as general needs made the development of a strong protective glass imperative. The non-brittle glass achievement mentioned, attracted more attention than the possibilities for better cement. Letters came from several parts of the country asking about this new glass so difficult to break. Now glass is not our specialty, but it appears that the Bausch & Lomb Optical Co., Rochester, N. Y., has a new glass that offers distinct possibilities. Several groups of lenses, when tested by the Bureau of Standards, withstood 125 or more blows on each side from a steel ball $\frac{5}{8}$ in. in diameter dropped from a height of 21 in., and also the impact of 2.95 ft.-lbs. which was delivered by a $1\frac{3}{8}$ -in. steel ball falling 8 ft. The common method of making goggle glass is to harden ordinary glass by a sudden uniform cooling which introduces a uniform strain and makes it very tough. Bausch & Lomb are said to be doing some simple thing to their processes which gives actually startling results.

* * *

A MANUAL OF CONCRETE MASONRY CONSTRUCTION, issued by the Portland Cement Association, 30 pages and cover, $8\frac{1}{2}$ x 11 in., describes and illustrates from photographs and drawings the various types of concrete building units which are available, and their proper use in the construction of walls chiefly, for dwellings.

IN THE ARTICLE, "THIRTEEN YEAR TEST OF A CONCRETE HOUSE," published in the March issue of CONCRETE, an error was made concerning the shingles. Instead of being laid "about 6 in. to the weather," they were laid 5 in. to the weather, and the third layer had a lap of 2 in. This is the actual measurement as found on the roof.

* * *

P. J. FREEMAN, for seven years engineer of Tests of the Pittsburgh Testing Laboratory has resigned to take up private consulting work (311 Ross Street, Pittsburgh). He has been retained by the Standard Inspection Co., as consulting engineer on problems relating chiefly to concrete materials and construction. Mr. Freeman was graduated from the University of Illinois in 1907 and later secured the degree of M. E. from the same institution.

* * *

HAVE YOU THESE 1922 NUMBERS OF "CONCRETE" TO SPARE:

January (Mill Edition);
February and March (Regular and Mill Editions);
May and July (Mill Editions)?

If you have and will send them to us we are willing for a limited time to extend your subscription for two months for each of the listed magazines sent to us in good condition.

* * *

WHAT IS UNDOUBTEDLY THE LARGEST SWIMMING TANK IN THE WORLD is nearing completion in San Francisco. It is built of concrete, 1000 ft. long and 100 ft. wide, except for a center portion which is 150 ft. across. This giant bath tub, it is figured, will accommodate 10,000 persons and will cost \$80,000. It will hold 6,300,000 gals. of water and will have a depth varying from 3 to 10 ft., with a 14-ft. diving pit. A racing course of 50 yds. is provided in the middle widened portion.

* * *

THE AVERAGE CONCRETE PRODUCTS PLANT IN IOWA IS ONLY 65% EFFICIENT says Ross Dowell, Secretary of the Iowa Concrete Products Association. Mr. Dowell sets down his reasons thus:

1. Selection of Aggregate—Loss 10 to 25%.
2. Improper Mixing—Loss 5 to 15%.
3. Lack of Enough Mixing Water—Loss 5 to 15%.
4. Improper Curing—Loss 5 to 15%.

Just how many of these losses are *you* suffering in *your* plant?

* * *

SOME CATALOGS ARE A GOOD DEAL MORE THAN THE WORD IMPLIES. They appeal to the imagination and furnish a mental cud for hours of munching or they are equally serviceable for quick reference and the needs of a special work or occasion. There is the catalog, for instance, of George B. Carpenter & Co., 440 No. Wells Street, Chicago, "manufacturers and distributors of general supplies and equipment for railroads, steamships, contractors, mills, power plants, machine shops and all forms of industrial activity"—with 1034 pages from which you can buy a circus tent or a screw eye, a saw rig, a camp stove, a locomotive boiler, pocket flash-light, adding machine, an oil can, a paint brush, roll roofing or an azimuth.

"OUR LITTLE ASSOCIATION HERE IS BEGINNING TO DELIVER THE GOODS," writes D. R. Collins, secretary of the Wisconsin Concrete Products Association. "It is mighty satisfactory to see the way the men are falling into line and really striving for a better product. It does your heart good to go into a plant and have a man who a year ago was making poor products proudly show you silt and colorimetric tests on his sand and have him tell you that he is using washed stuff from now on. Then someone else shows you an order for a small crusher with which he is going to produce coarse aggregate to strengthen his block and cut down the cost."

* * *

UNSIGHTLY PLASTER CRACKS ARE COMMON, BUT AVOIDABLE. New houses commonly undergo a period of unsightly plaster cracks in both walls and ceilings; people take this for granted, as a matter of course. They figure upon a certain amount of settlement and shrinkage and movement in the frame of the building, which result in cracks which are not to be avoided. It ruins a lot of decorations for which considerable money was spent and a good deal of patching and fixing has to be done to make it right. Such cracks are not necessary; they may be avoided, and in avoiding them homes may be made much more nearly fireproof—all this at a very small additional expense, for metal lath applied over critical points of the frame. Any manufacturer or the Associated Metal Lath Mfrs. will supply detailed information. The extra expense is made trivial by the repairs necessary through damage to decorations and plaster following the other common type of construction.

* * *

SPECIFICATIONS FOR METAL LATH HAVE BEEN ISSUED BY THE ASSOCIATED METAL LATH MANUFACTURERS, as agreed upon by the principal manufacturers of expanded metal lath and approved by the American Specification Institute. In presenting this new specification it is pointed out that for years the various manufacturers of metal lath have given out slightly conflicting recommendations on the use of the product. It has been very difficult for the companies to arrive at a uniform recommendation because they are manufacturing some 73 different kinds, weights, gauges and qualities of metal lath. The present specifications have reduced this great number to 10 different weights simplifying the sale, distribution and specifying of metal lath.

The present specifications cover the quality of material and methods of application of all types of metal lath, expanded from sheets and used for the various types of construction. Seventeen separate specifications are included, each one covering some particular construction. The specifications are written upon the basis of weight only, which it is pointed out will insure equality of competition through basic costs and facilities for accurate inspection in the field. Detail drawings are included to illustrate the various types of construction covered by this specification.

* * *

HOW TO MAKE WATERPROOF CONCRETE—Every day the question is asked and while the conditions vary, the fundamentals are the same. A recent Portland Cement Association bulletin summarized these fundamentals briefly and here they are:

1. All portions of the structure should be strong enough to resist

the head of water, either internal or external, to which the concrete may be subjected.

- 2. Use clean, well graded aggregates.
- 3. Use a relatively rich mixture, a 1:2:3, or better 1:1½:3.
- 4. Use the minimum amount of mixing water that will give a workable, plastic consistency; not over 6 gallons per sack of cement.
- 5. Mix the concrete thoroughly, at least 1½ minutes per batch mixer.
- 6. Place the concrete carefully in layers 6 to 12-in. deep, spading or rodding it thoroughly to prevent the formation of stone pockets or voids.
- 7. If possible place the concrete in one continuous operation to avoid construction joints. If placing is interrupted, be sure to get a good bond between the fresh concrete and that placed previously.
- 8. Keep the concrete warm and damp for the first ten days.

In tests conducted by the U. S. Bureau of Standards, thin slabs of a lean (1:6) portland cement mortar and 1:1½:2 concrete were subjected to a water pressure of 60 lbs. per sq. in. This pressure is equivalent to a 138-ft. head of water. Although water penetrated through 1½ in. limestone slabs in periods ranging from 20 seconds to 20 minutes, it took 3½ hours for water to penetrate through a 2-in. slab of 1:6 mortar, while at the end of 24 hours, when the test was terminated, the 2-in. slab of 1:1½:2 concrete was still dry.

* * *

COST FIGURES FOR BUILDING MATERIALS were secured by the National Builders Supply Association from the large cities of the country

in fourteen different states with the result as shown below. Two of these cities showed higher prices in 1923 than in 1920, explaining this difference by stating that their trucking charges now are very much greater than they were in 1920. These increased price cities were lumped with the decreased price cities and in spite of this being done, the table of comparative prices showed that there was no excuse for the statement of the American Construction Council as reported in the daily press. Although afterwards the American Construction Council officially denied having given out the statement about the high price of materials, the fact remains, says the N. B. S. A., that the contracting group of the construction industry is too anxious upon meagre or no information to attract unfavorable attention to the other groups associated with them in the building industry.

COMPARATIVE RETAIL DELIVERED PRICES OF BASIC BUILDING MATERIALS		
	June 1, 1920	June 1, 1923
Sand, per cu. yd.	1.947	1.721
Stone, per ton	2.264	2.114
Common Brick, per M.	23.00	19.43
Lime, per ton	22.03	19.68
Portland Cement, per sack	.983	.823
Hollow Partition Tile, per M.	190.00	152.70
Metal Lath, per sq. yd.	.321	.231
Plaster, per ton	21.55	18.93

What Properties and Methods of Making Concrete Require Further Investigation?

(Continued from page 14)

the limits of this paper permit, and pending the conclusion of such investigations as would show conclusively that different cements are needed for different uses, and would furthermore indicate what the characteristics of the different types should be, it were well to go into this discussion but briefly.

Those but casually acquainted with the industry are surprised that a product made to meet our present standards can be produced under such a set of widely varying plant procedures and equipment as now used. Though the product may be "standardized" it is quite evident that its methods of production are not. While it is generally believed that this wide latitude in methods does produce the same character of product, we are not convinced that such is the case, especially in view of the incompleteness of the methods used in examining the marketed product. The majority of plants have carried on certain studies as to the effect on the finished product of one or more changes in plant procedure, but these have been isolated and not well correlated and the finished product has been examined only according to our very imperfect methods. There is needed a broad, well-developed, correlated investigation, conducted in a number of plants of the question of the quality of cement as affected by the different types of equipment now generally used. (This could be readily made of much interest to the manufacturer by obtaining data as to the efficiency of these methods.) Indeed at the present time the only incentive for such a study is the matter of needed economies in production, and the limited studies already made have shown the economic value of certain changes in methods—as the waste heat boiler. Furthermore, in this case it seems reasonable to believe that the required care

demand of the kiln operator, in order to insure a uniform delivery of heat to the boiler, has produced a change in the cement, more marked than is generally realized. Studies of the efficiency of the grinding apparatus, not only as to the relative operating costs of the several types of machines available, but extended as they should be, to the efficiency of the resulting cements would be of extreme value to both consumer and producer. How interesting would be an investigation on the properties of the resulting cements in which the sole variable in the methods of production would be the use of wet or dry raw mixes! Fuel economy demands a thorough study of all available types of kilns and furnaces and of necessity such a study must include the question of the quality of the cement produced. May not such studies result in our specifying what methods of production are desired in addition to the physical properties, just as we now specify steel of certain physical properties made by open hearth or bessemer process?

This paper has been given a title that is a slight alteration of the general topic of this colloquium. Permit us in conclusion to suggest to this group gathered here for a deductive study of concrete, another slight variation of a well-known slogan as a thought to have before it for the next few years—"Concrete for Study." We must confess that we hesitated for some time before choosing "cement" or "concrete" for the first word of our slogan but the word used was adopted largely because we did not wish to deviate too much from the original. However, if we will remember that nature has produced, of the essentials entering into concrete giving adequate service, the aggregate, the water and especially the conditions under which it is used, while man has produced the cement alone, we will acknowledge that man must fit his product to nature's, for he can change the aggregate but little, the water still less and the conditions practically not at all. Hence, though the vital study of concrete must be a study of cement, we suggest "Concrete for Study."

THE INFLUENCE OF METHODS OF PROPORTIONING AND MIXING

By R. B. YOUNG

There is the question of limitations of the new methods of determining proportions in concrete. Under certain conditions, concrete mixes can be designed by properly determining the proportion so as to give the strength sought. Under other conditions equally likely to be met on the job, the methods will not give the results required. Lack of knowledge on the part of the engineer as to when the method he employs can be used with safety, may cause failure to get the expected results.

More exact methods for measuring the raw materials of concrete on the job can be studied to advantage. It is not generally appreciated that under average conditions our present methods of measuring concrete materials, particularly in the case of fine aggregate, result in lack of uniformity in the concrete mixtures and that their inherent errors tend to produce undersanded and permeable concrete more susceptible to the action of destructive agencies such as frosts, alkali or seawater. A 10 to 15% increase in cement requirements brought about by improper measurements of fine aggregate is not unusual and the output of the construction plant is also reduced.

The relationship between the time during which a concrete is mixed and its strength at a given period is fairly well established, but little is known as to the relative effectiveness of different mechanical mixers. Large-scale experiments on mixers of different makes and different capacities are needed.

Phases of proportioning and mixing which could be studied with advantage include the influence of plant layout and construction on proportioning and mixing concrete, possible re-mixing action during the transfer of concrete in the chutes and methods of charging a mixer. Present equipment could be modified if experiments demonstrated that other methods gave better concrete or were more economical in materials and power.

BEHAVIOR OF CONCRETE UNDER SERVICE CONDITIONS—CONCRETE EXPOSED TO ATMOSPHERIC CONDITIONS

By P. J. FREEMAN

A careful study of many concrete structures which have deteriorated under atmospheric conditions indicates that concrete should be produced which has the qualities necessary to meet the demands of the particular service involved rather than concrete having only the required strength. The impermeability of the concrete is a very important factor. Specific instances cited give examples of disintegration caused by the water percolating into the permeable concrete with later freezing and thawing, producing disintegration. Disintegration is commonly found close to construction joints and near the edges of exposed surfaces.

It is not sufficient to keep concrete from freezing merely while it is being mixed and placed and for a short time afterward. Concrete must be kept warm in order to allow it to set properly.

The so-called sulfate disintegration is one of two kinds of disintegration noted in the Cascade Tunnel. According to Charles A. Newhall, chemical engineer, sulfate disintegration is always accompanied by swelling of the concrete and the formation of a white mud abnormally high in sulfur content.

It is the result of a reaction between the sulfurous fumes from the locomotive flues and the cement of the concrete. In another type of disintegration, the concrete softened and became mushy without swelling or the formation of white mud. This disintegration is due to the actual solution and removal of the cement by water over and through an originally porous concrete. Moisture is essential to sulfate disintegration and when once started it progresses very slowly. A somewhat similar condition has been noted in the disintegration of a concrete highway base.

Designers of concrete realize that they must consider the atmospheric conditions to which the concrete will be subjected and eliminate from their design any features which would tend to cause or permit water to percolate into the concrete. More careful records and tests should be made and ideas exchanged concerning troubles arising in concrete construction, in order that facts may be obtained to make satisfactory investigations to eliminate most of the unsatisfactory conditions which now exist.

BEHAVIOR OF CONCRETE UNDER SERVICE CONDITIONS—CONCRETE EXPOSED TO ALKALINE CONDITIONS

By G. M. WILLIAMS

In numerous instances, irrigation structures, foundations and other concrete work have shown signs of failure after short exposure to the salts in the soil. In the Western states, the excessive application of irrigation water together with poor drainage facilities, has resulted in a gradual rising of the soil water level which has brought about a high concentration of salts at the ground surface and a few feet

below. It is this condition which is responsible for most cases of disintegration that have been noted, although there are localities outside of the irrigated section where surface concentrations of salt are small and deterioration occurs some distance below the surface. Early conclusions drawn from laboratory investigations classified the disintegration of cement by alkali salts as principally due to reaction between these salts and the calcium hydroxide necessarily present in set cement. As a result of these reactions relatively insoluble new compounds were believed to be formed in the body of the cement structure. These new compounds having greater weight, and requiring greater space than the calcium hydroxide replaced, force apart particles of cement thus weakening or breaking the binding material.

Other conclusions were that cement mortar or concrete can be disintegrated by mechanical means exerted by the crystallization of almost any salt in the pores if a sufficient amount of it is permitted to accumulate and a rapid formation of crystals is brought about by drying. Porous stone, brick and other materials are disintegrated in the same manner. In the presence of sea water and similar sulfate chloride solutions the most soluble element in the cement is the lime. If the lime of the cement is carbonized it is practically insoluble.

Experiments were made by the Bureau of Standards and field investigations involved the manufacture in a commercial factory of sixteen varieties of 8-in. cement drain tile which was shipped to 11 localities in 8 of which severe alkali conditions were encountered. These tests of drain tile were later supplemented by the installation of concrete blocks in 8 districts in the West. The ground waters in these districts varied considerably in concentrations and constituents, but in most cases the sulfates predominated. In one or two instances the quantities of chlorides and sulfates were practically equal. Sodium or magnesium was the base usually present in greatest quantity with much calcium in a few cases.

This investigation, comprising concrete and mortars of the highest quality and identical specimens exposed in widely separated districts has resulted in confirming and extending the conclusions found in the previous studies. They are summarized as follows:

1. The best quality of mortar or concrete may be disintegrated in sulfate soils and waters. The deterioration in chloride or carbonate waters appears to be very slow or almost entirely lacking.
2. Rapidity of disintegration is proportional to the sulfate content of the water.
3. Frost action appears to accelerate disintegration in sulfate waters.
4. Carbonizing of the lime at and near the outer surface of a structure will not prevent disintegration. While this carbonized coat may be immune or very slowly affected, it is permeable and the uncarbonized portions within may be attacked and result in the shelling off of the carbonized surface.
5. Tar protective coatings are not permanent.
6. Concentrations of alkali waters may vary as much as several hundred per cent in distances only a few feet apart.

Experiments conducted by the Calgary branch of the Engineering Institute of Canada with blocks of different qualities of concrete some of which were coated with various surface preparations when exposed to sulfate waters led to the same conclusions as drawn from the Bureau of Standards study.

All of the investigations are considered definitely fixing the problem and demonstrating the fact that disintegration is primarily a chemical action, rather than a physical disruption and indicating the variable factors and conditions which must be met in practical work. The second phase of the work involves the discovery of means, materials and methods for eliminating the possibility of disintegration in future work. Two distinct methods of approach are available. It is possible that a continuation of the field studies by the preparation of many different concretes containing various materials may lead to the production of a concrete which will be immune to attack. The second method is to study in the laboratory the constituents of cement and the reactions which take place when they come in contact with the different salts found in the soil. This, of course, requires a study of the reactions involved in the hardening and setting of cement, which in itself is a subject concerning which much is yet unknown. This second method is the scientific method of attack and will no doubt be more effective than the former.

The status of the use of concrete in alkaline soils is summed up briefly as follows:

1. In many districts of the Western states and Canada there are areas where the salt content of the soil is high and concrete cannot be used with assurance of success.
2. Study of field conditions indicates that deterioration of concrete structures is almost entirely confined to regions where the sulfate type predominates. Good quality concrete is being successfully used in chloride and carbonate soils.
3. Rapidity of disintegration varies directly as the sulfate concentration.
4. Where concentrations are permanently low, good quality concrete appears to have a life which fully justifies its use.
5. Concentration of salt in ground water may be extremely variable at points short distances apart. There also appear to be seasonal or yearly variations in some districts.
6. Concrete of high quality is most resistant to action. High quality for exposure to alkaline conditions is measured by impermeability or resistance to passage of water through the mass under pressure. The one big factor necessary to secure low permeability is high cement content, so that high compressive strength can generally be used as a criterion of low permeability. Consistency, within practical working limits, and gradation of aggregate are secondary factors in obtaining a concrete of low permeability.
7. Where alkali conditions are bad, the factor of safety against failure can be greatly increased by employing proper drainage precautions.
8. The employment of a membrane waterproofing may prevent action for a time at least, but such a method is not practicable under all conditions.
9. Portland cement, as now constituted, is inherently subject to attack by sulfates in the soil and ground water and the practical and final settlement of the alkali-concrete problem is dependent upon modifications of, or the discovery of some material which may be added to, portland cement to make it immune to such action.

A Concrete Masonry Home Adjoining the White House

By WILLIAM F. LOCKHARDT
Portland Cement Association

Concrete masonry construction was used for the 1923 Model House built in the nation's capital as the nucleus of the "Better Homes in America" movement sponsored by the General Federation of Women's Clubs. Today a concrete block house stands on the Sherman Monument Plaza, a part of the Executive Grounds, to serve as a demonstration of the speed, economy and durability of this type of construction.

Back of the construction of this house, complete in five weeks time from the breaking of ground by Herbert Hoover, lies an interesting story. The house itself is a reproduction in permanent materials of the old John Howard Payne homestead at Easthampton, L. I. As the one hundredth anniversary of the writing of his world-famous song, "Home, Sweet Home," was observed May 8th this year it seemed fitting to choose his home as a model for the demonstration house in Washington.

Donn Barber, New York architect, prepared the drawings for the modernized version of the Payne homestead, adhering as closely as was practicable to the original dimensions. The present day house, however, has the many modern conveniences lacking in the original, and as a result some minor departures from the original were necessary.

Preliminary negotiations for the construction of the house from materials donated by the various national material interests in the cause of better housing were completed April 20.

The following day, Saturday, was spent in obtaining the necessary permits from the various governmental departments concerned and in finding a contractor with the skill and organization to handle a ten weeks job of masonry construction in five weeks time, as the house had to be ready for furnishing by May 26.

Charles H. Tompkins volunteered the services of his organization, which at that time had about fifteen other jobs under way in the city, and arrangements were made to start construction immediately following the formal breaking of ground on Monday morning at 11 o'clock. By Monday night the footings were in, as there was no cellar to dig, and the following morning the work of erecting the concrete block walls started.

The progress pictures, Figs. 2 to 7, show the growth of the house the first week. The end of the first week saw the walls up, the roof sheathed, and the partitions in place ready for lathing. A question over the size and exact location of the rear porch retarded the building of this part of the house, where a part of the wall may be seen to be omitted. After the roof was framed, plastering was started and from that point to the completion of the job progress was no less rapid though not as conspicuous.

The house is 25 ft. 8 in. x 38 ft. 5 in. in plan with a porch in the rear 12 ft. x 14 ft. It is two stories high and contains seven rooms, breakfast nook or pullman-dining alcove, and two baths. The plans are shown in Fig. 8.

The site selected for the erection of the house is immediately south of the Treasury Building, and across Executive street from the White House, on the Sherman Monument Plaza. This location was chosen because



FIG. 1—DEDICATION BY PRESIDENT HARDING OF CONCRETE BLOCK AND STUCCO REPLICA OF ORIGINAL "HOME SWEET HOME."

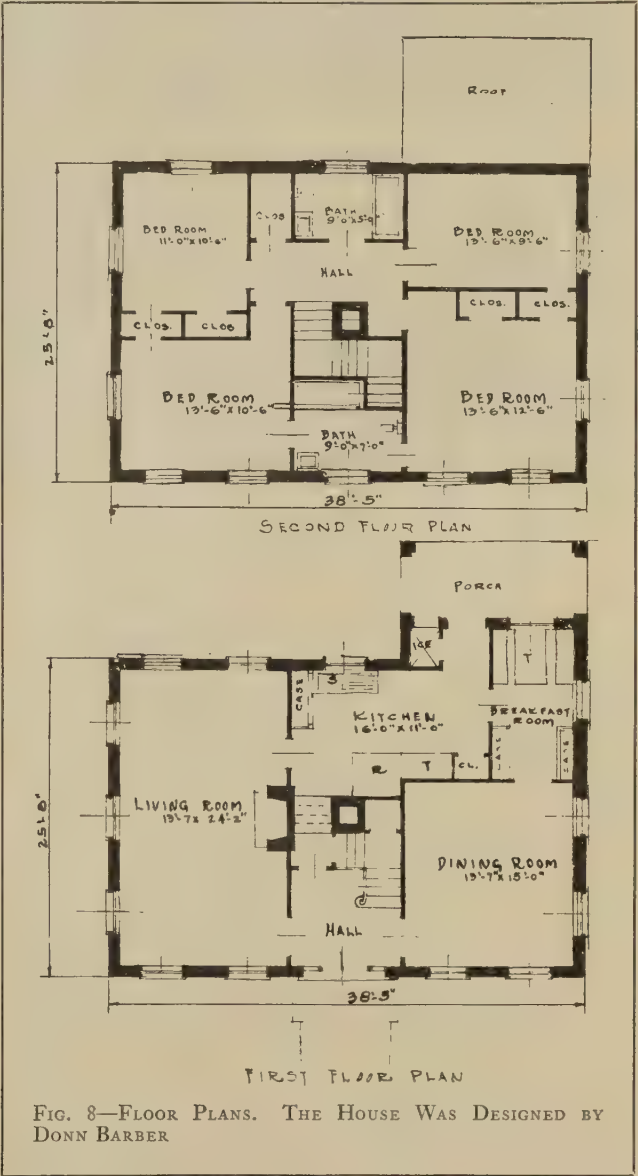


FIG. 8—FLOOR PLANS. THE HOUSE WAS DESIGNED BY DONN BARBER

the house was to be used during the Shrine Convention as the Information Bureau, and the present site at the corner of Fifteenth street and Pennsylvania avenue is probably the most accessible in Washington. It is intended to move the house after "Better Homes Week" to a permanent site in one of the near-by parks where it can be maintained by the General Federation

THE HOUSE IN PROGRESS

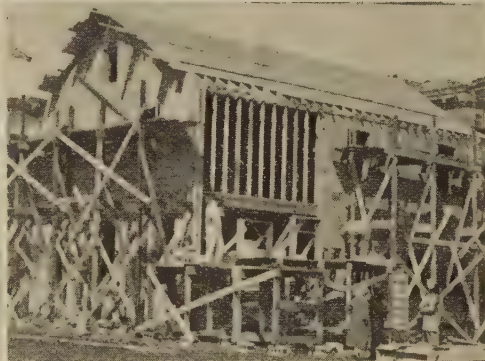
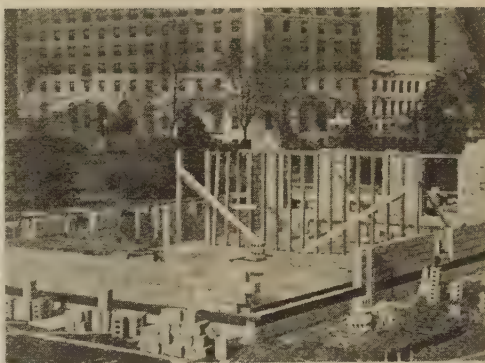


Fig. 2—Noon, Second Day—Block in Place up to Level of Wood Sill Built in for Convenience in Subsequent Moving of House. Sill Was Set and 1st Floor Beams Placed Complete, Second Day, the Footings Having Been Concreted First Day After Secretary Hoover Broke Ground

Fig. 3—Third Day—East Wall up to Lintels of First Story Windows; Remainder of Wall Waist High, Except for Rear Porch Opening; First Floor Underflooring Complete

Fig. 4—Fourth Day, Walls Complete to Second Tier of Beams; Interior Partitions Complete; Beams in Place for Part of Second Floor; Wall at Rear Porch Still Left Open Waiting for Information as to Size

Fig. 5—Fifth Day, Second Story Walls up to Window Sills; Window Frames Placed; Second Story Subflooring Complete

Fig. 6—Sixth Day, Second Story Walls, Partitions Practically Complete; Ceiling Beams Being Set

Fig. 7—Seventh Day, Roof On; Rear Porch Scaffold High

of Women's Clubs or some similar organization in cooperation with the proper Government departments, as a permanent demonstration house for better home-construction and housekeeping methods.

As previously mentioned, there is no cellar under the house as it now stands, although there will be one in its final location. A monolithic concrete foundation was placed 12 in. below the level of the lawn and the block construction started on top of the footing. In order to make provision for the future removal of the house, an 8-in x 8-in. sill timber was built into the walls about 1 ft. above grade. This timber is braced and bolted to form a rigid frame on which the superstructure walls are carried, so that when the time for removal comes it will only be necessary to cut holes through the low foundation walls below the sill, run 12-in. x 12-in. needles under the sill and pick up the house from its foundations, the sill insuring an even distribution of the load. This is of course a special feature that would not be found ordinarily in a concrete block house, and when this house is set on its own permanent foundations the sill will be omitted.

The concrete masonry construction followed the recommendations of the Department of Commerce Building Code, better known as the "Hoover" Building Code. Standard 8-in. x 8-in. x 16-in. concrete block were used throughout. The block were made on an Anchor stripper machine and were furnished at cost through the cooperation of the United Supply Co., Washington. The block walls before the stucco was applied made an excellent appearance and caused much favorable comment. A 1:3 mortar was used for laying the block.



FIG. 9—STUCCO WORK IN PROGRESS
FIG. 10—HOUSE COMPLETE READY FOR DEDICATION



FIG. 11—AT NIGHT, WITH THE WASHINGTON MONUMENT

Because of the anticipated extremely heavy loading throughout "Shriners Week" and subsequently during demonstrations, unusually heavy framing was used for the first and second floors and for the first story partitions. The first and second floor beams are 2 in. x 10 in. spaced 12 in. on centers instead of the usual 16 in. while the first story bearing partitions are built of 3-in. x 4-in. studs instead of 2-in. x 4-in. Seven-eighths in. underfloors were installed throughout.

All trim for the house was furnished by the Curtis Companies. A Ritter oak parquet floor was used for the living room, and Beaver Cork Tile in the dining room and breakfast alcove. Beaver Lino-tile floors were installed in the kitchen and bathrooms. The bedrooms have maple, beech and birch floors.

Plastering throughout was on metal lath in order to add to the fire resistance of the interior construction and to withstand strains incidental to moving. Crane plumbing was connected to brass piping and copper flashing, gutters and leaders were used in connection with the Vendor slate roof. General Electric wiring in flexible conduit was used throughout with Hunter fixtures. Gas range, Hoffman hot-water heater and Hungerford copper range-boiler were installed. Arnold & North of New York furnished the mantel and the Fish Brick Sales Co. the hand made brick for the fireplace. White portland cement stucco was used for the exterior finish.

Because of the many different interests involved, many of whom had to ship their material to Washington from points as distant as Clinton, Iowa, and because of the fact that negotiations for these materials were necessarily under way in many cases while construction was actually progressing, there were minor delays and over-lapping of work that could have been avoided had there been a week's start in which to line up these items. It is probable that under these conditions the contractor could have beaten his already remarkable time by at least a week.

For the General Federation of Women's Clubs the work was under the immediate supervision of Miss Lida Hafford, Director. D. V. Stroop was superintendent of construction for the Charles H. Tompkins Co.

Want Better Cement Contract

Acting on a complaint of six cement manufacturers to Herbert Hoover, Secretary of Commerce, that the building situation is injured by prevalent practice among contractors of over-ordering, the Associated General Contractors made an effort to discourage the practice, and steps were taken to investigate the question of its prevalence, the causes for over-ordering and the possibility of finding a permanent remedy.

The points made by the cement people either directly or by inference, as interpreted by the A. G. C., are as follows:

First—Construction companies either through excessive caution or a desire to speculate at the expense of manufacturers, contract for cement, greatly in excess of their requirements—the excess amount as indicated by a number of cases investigated, averaging 40% of the actual needs.

Second—Cement is sold, presumably against the desire of manufacturers, under a fixed price "specific job contracts," which is cancellable by the contractor but to which the manufacturers submit as a protection to the public against the evils of speculation.

Third—The demand for cement should be more uniformly spread and over-ordering or other wasteful and selfish methods in the building industry should be abandoned if the industry is to function properly.

In reply to these points the A. G. C. offers an analysis:

First—Over-ordering or the duplicating of orders does occur to a very limited extent when construction companies are bound by a completion time limit and penalty, under a contract which grants no extension of time for delay in material delivery, or where such delay introduces excessive costs; but no instance has so far been found where over-ordering was practiced merely as a means of speculation. None of the signatories to this communication has knowingly over-ordered cement for any purpose or encountered the practice directly among other members of the industry.

The volume of cement used by contractors has been estimated by the cement manufacturers at 40% of their output and if all contractors over-ordered 40%, the excess orders would equal some 16% of the total production. That all contractors do not over-order 40% is obvious. Ten per cent is probably an excessive average, and this amount, in so far as construction companies are concerned, would represent excess orders of about 4% of the total production.

Second—Cement is almost universally sold under a loose form of contract, which guarantees the price, but which does not bind the seller to deliver a given quantity of material within a given time. Therefore, since the construction company is almost invariably bound to its client under a time of completion penalty, and also faces an excessive loss for delayed material, it commonly occurs that the time element is a more vital factor than a reasonable variation of price. In other words, the construction company sells short on time as well as on price and under the existing form of material contract, it cannot cover itself against non-delivery.

It is important to take cognizance of the fact that on certain types of highly organized construction work, notably highways, which depend upon continuity of material delivery for their success, a delay in material delivery may entail an unavoidable overhead expense of from \$30.00 to \$50.00 per hour. Such an unproductive expenditure is capable of ruining almost any construction company and they dare not trifle with the question of delayed material. If the manufacturer and the dealer, who receives a commission on all cement used in his territory, will assume responsibility for delivery at a given time, the practice of over-ordering or duplicating can doubtless be eliminated. It has birth in the trade practices of cement selling and upon revision of these practices depends its correction. Under existing conditions, it is surprising that the extent of over-ordering is not greater.

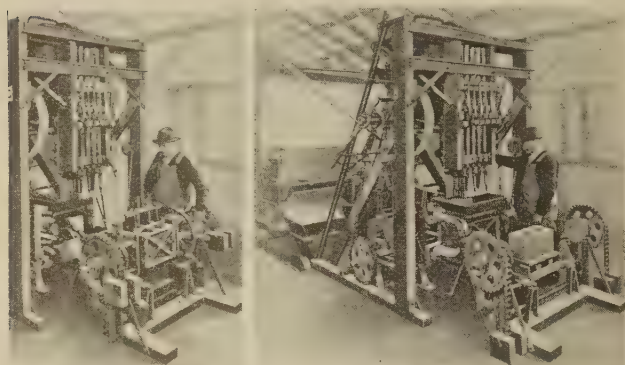
Since the manufacturer does not agree to deliver at a given time or rate and since the owner demands his project at a given time, the construction company is obliged to accept responsibility for contingencies which neither of these will assume. In the construction of a modern office building, there may be a score of industries who pass this same contingency along to the construction company, and it is almost inevitable, therefore, that as long as the present form of material contract exists, construction companies here and there will over-order as a means of self preservation.

The present form of contract employed in the purchase of cement and various other material is no instrument of construction companies. In fact, they are repeatedly injured by its use and have sought its abandonment. Construction is salted with such instruments, which in the public interest as well as in the interest of the industry should be substituted by a system of bona fide mutual contracts, harmonizing with the major construction agreement.

Reliable construction companies have often sought to enter a bona fide non-cancellable contract guaranteeing delivery and acceptance, and relieving seller from delays of transportation, but this offer has been declined. In certain instances where the inability to deliver cement was attributed to lack of transportation, and construction companies offered to provide transportation off dock either by water or rail, these companies were found to be over-sold and could not deliver. Over-selling as well as over-ordering is an important factor in the expansion period of the construction industry. Any recession of the manufacturers, not only of cement but of other materials, from a stand against the adoption of mutual, non-cancellable sale contracts will unquestionably meet with sincere cooperation from the country's construction companies.

Third—The cement companies make a sound constructive suggestion that the demand for cement be more uniformly distributed and that all wasteful and selfish practices in the industry be abandoned. To this there is but one answer—a cooperative examination of existing methods, impartial analysis of the economics and ethics involved and a sincere effort on the part of each industry to govern itself with due regard for the commercial rights of every other. It was partly to

institute a move in this direction that an open conference of those industries involved in construction was sought last February by the Associated General Contractors.



Stripper Block Machine of New Type

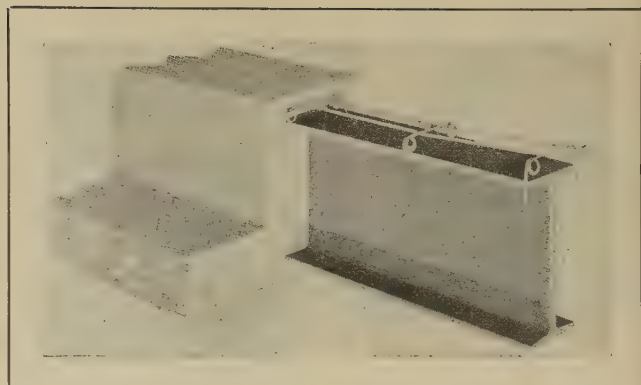
These two pictures show a new kind of equipment for making concrete block. It is called a Roll-Over Stripper machine, made by the Ideal Concrete Machinery Co., Cincinnati, O. The special feature of the machine is the carefully balanced mold box which rolls on a track. In the loading and tamping position the box is under the tamper, the scraping hopper is forward over the box. The operator handles the automatic tamper in the regular way, throwing in all the tamp feet at once, and at the same time feeds the concrete into the box, using the standard conveyor and feeder.

As soon as the tamping is completed, the scraping hopper is pulled back by power, carrying the surplus concrete back onto a plate ready to be used in making the next block. The mold box is then rolled over into the second position. The operator presses a foot lever which throws in a clutch, and by means of cams the block is forced out of the mold box onto a pallet placed on a counter-balanced table. As soon as the block is stripped out, the mold box is rolled back and the scraping hopper brought forward for loading, and the operation repeated.

The advantages claimed for the machine are in the fact that the block are not made on pallets but are delivered onto them after being completed, so that either standard Ideal pallets may be used or ordinary wooden ones. In case wooden pallets are used, the same pallet equipment and mold box will take care of either 8-in., 10-in. or 12-in. block, and will also take care of two 5x8x12 standard Ideal tile, at one operation. To change from one type of building unit to another, one size to another, it is only necessary to change the core in the mold box and the feed on the tamper. The block is carried away and the empty pallet placed in the machine while the next block is being made. That is eliminating lost time with the machine itself. Two of these machines are in operation: one at the plant of the Oakland Sand & Gravel Co., Rochester, Mich., the other at the plant of William Koenig, Loretta and Lockman Aves., Cincinnati.

Reed Soffit Clips

Reed soffit clips, the use of which is illustrated in the accompanying figure are recommended by the manufacturers, the Union Steel Products Co., Ltd., Albion, Mich., as an insurance against defective soffits, where structural steel members are to be protected with concrete.



It is claimed for the Reed clip that it is built in sections of handy length, the different cross clips being held in place by one or more longitudinal members welded on. Tests are mentioned as having demonstrated that this electric spot-welding is stronger than the wire and as only genuine high grade steel can be electrically spot-welded, this process insures not only a strong construction, but absolutely high grade materials throughout.

It is further claimed for the Reed clips that they are low in first cost, easily handled and applied, and assure a permanent work.

It is mentioned as the only clip which permits the worker to fasten to the end of the beam or girder, keeping his work ahead of him the entire length of the member. In applying the clip, the mechanic never leaves his position. He simply bends each clip over the flange and forces the fabric ahead the required distance.

The Reed clip does not project beyond the flanges of the beam and therefore in no way obstructs the flow when concrete is poured, continuous tamping being permitted for the entire length of the beam.

The loop in the clip causes it to project about 1 in. below the flange so that the steel is thoroughly embedded in the concrete furnishing an adequate bond and full reinforcement.

The clip ordinarily comes in convenient 5-ft. lengths with clipping members spaced 12 in. on centers. One or more longitudinals are ordinarily supplied, depending upon the width.

Lakewood Graderooter

The picture shows the new Lakewood Graderooter, intended for use in scarifying subgrade preliminary to mechanical subgrading. Some contractors are using it in place of a rooter plow and it is being used for

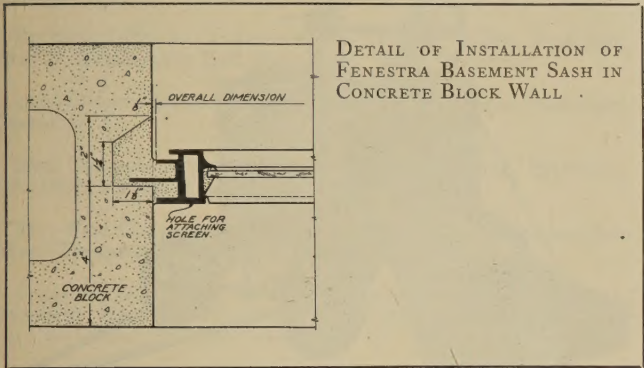


maintenance work by state as well as county highway departments. It is furnished with two sets of five teeth each and one special manganese tooth for particularly heavy work. The machine weighs about 1300 lbs. and can be furnished for tractor or team hitch.

Installing Steel Sash With Concrete Block

Two sizes of steel basement windows offered by the Detroit Steel Products Co., are particularly designed to fit into concrete block construction. One is the two light, 14-in. x 20-in. glass. The over-all height of this Fenestra window is 23¼ in.—equal to the height of three concrete blocks laid up with ½-in. mortar joints and a 1¾-in. sill. The width is equal to two concrete blocks laid end to end.

The other Fenestra window has three 12-in. x 18-in. glass lights. The over-all height of this window when



DETAIL OF INSTALLATION OF
FENESTRA BASEMENT SASH IN
CONCRETE BLOCK WALL

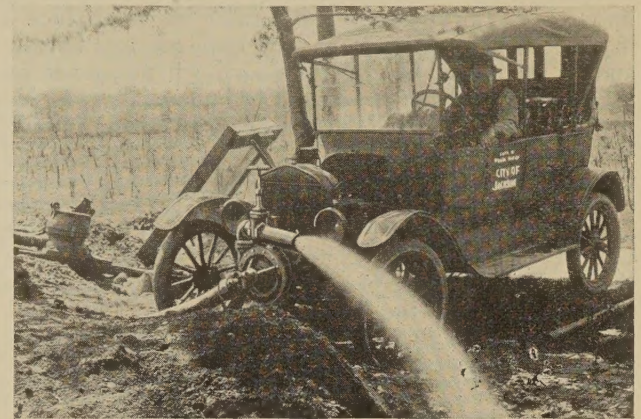
a 4-in. sill is used equals the height of three blocks. The width is equal to two and one-half blocks.

In setting the window, stand the equal channel leg frame on two blocks or pieces of brick either 1¾ in. or 4 in. thick, to provide for the sill, according to the size of the window as explained above. The best type of blocks for the jambs are those with slotted ends. In laying up the jamb, set the blocks so that the extending fin will set into the slot and the outside channel leg will come up to the end of the block as is shown in the detail.

Then grout in around the extending fin in the slot and smooth off even with the edge of the block to prevent binding the ventilator. Trowel finish or pour the sill snugly under the channel frame so as to make it weather proof. The equal leg channel frame at the head makes it easy to put in cement for a snug fit against the wall plate, lintel or bond timber.

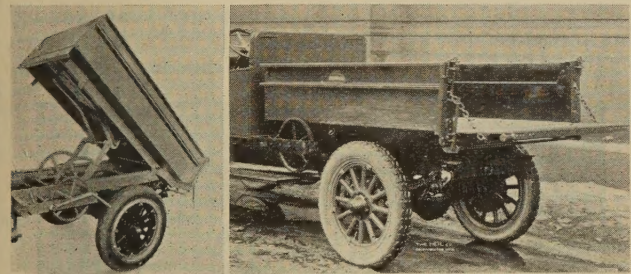
is fitted with a two-way lock which locks the body as it rises so that it cannot slip back on the operator and also locks it in the down position so that if extra heavy weight is put on the rear it will not tip up.

The body weighs 975 lbs. complete, ready for mounting on the truck, which is within the body allowance of all the truck manufacturers. The material used in the body is No. 12 gauge and the flanging of the upper set of sides and lower set of sides outward gives additional strength and rigidity. The method of elevating and lowering the tail gate is such that the body can be used for spreading gravel as well as for a platform job.



The Barton Portable Pumper

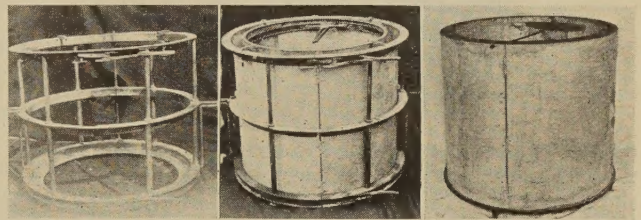
A circular issued by the Barton Products Co., Jackson, Mich., describes a pump attachment for Ford cars. It is intended for use in construction and road work, public works department, fire protection, irrigation and so on. It is a pump of the portable type of special design, very light in weight with simple connections, so as to be put on at the front end of a Ford and left on while driving. The first installation of the pump and attachments requires about one and a half hours; thereafter the pump may be connected or disconnected in two minutes. The announcement is to the effect that the Barton Pumper will lift water by suction 26 ft. and has a normal discharging capacity of from 200 to 250 gal. per minute at 20 lbs. pressure, at the rate of 18 mi. per hour driving speed.



HEIL HAND HOIST DUMP, 1½-YD. BODY

Hand Dump Body

The pictures show the Heil Co.'s Hand Dump for any one-ton dump—1½-yd. body, 7 ft. x 4 ft. x 1 ft. deep with upper sides 18 in., capacity 42 cu. ft. The distance from the top of sub-frame to the floor of the body is 9 in. which is used by 1-in. wood sills and two 4-in. channels. It is pointed out that with an underbody hoist it is possible to utilize all of the loading space back of the cab, allowing a lower sided body than where the hoist is back of the cab. A double acting feature of the tail gate makes it possible for the tail gate to be unsuspended level with the floor of the body. The hoist



THE PICTURES SHOW A MASTER MOLD; A MASTER MOLD IN PLACE OVER THE MOLD PROPER AND THE SHEET METAL MOLDS AFTER REMOVAL OF THE MASTER MOLD WITH AN INNER BRACE IN PLACE

The Monroe Pipe Mold

The object sought in the development of the Monroe mold for making concrete drain tile and pipe was to provide equipment which would make it possible to employ a mix with plenty of water in it, the product to be kept in the mold until sufficiently hard without tying up the entire molding equipment by such an operation. This is done by a very simple inner and outer mold made of No. 28 galvanized iron, held rigidly in the filling operation by a so-called master mold, consisting of a frame-work of angle and channel iron which is tightened up around the mold to be

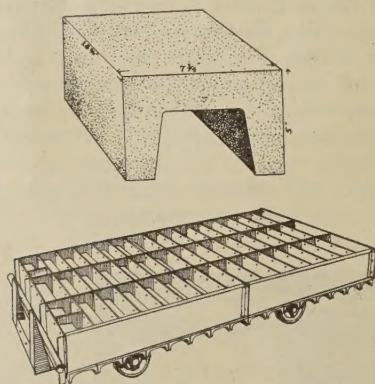
released as soon as the product is set down in the place where it is going to harden. Thus, production with the Monroe mold consists in having a master mold equipment for each size to be made and sufficient outer and inner walls of the galvanized metal for the products turned out in one day, and probably some 6 to 12 expanding rings and 2 or 3 dozen adjustable braces which are used in holding the inner and outer walls in place.

Block That Have Lock Joints

There have been two developments recently in equipment for the manufacture of concrete building units of the locking type, so formed as to produce a modified tongue and groove lock both top and bottom and at the ends. One is the Four-Lock tile, made by the Interlocking Metal Forms Corp., Tuckahoe, N. Y., produced in steel molds in sizes 8x4x4, 8x8x8, 8x8x12, 8x8x16 and 8x8x24, with both beveled and tooled edges. The other equipment is a machine for the production of tamped products, known as Lock Block, the machinery being sold by the Concrete Block Machine Co., 111 Hamilton St., Newark, N. J. It operates on the face down principle, the cores being withdrawn horizontally and the block tipped over, the same machine producing the various specials ordinarily required, in addition to fractional block.

Bradt's Building Tile

Bradt's concrete building tile has a vertical section like a letter U upside down. The standard tile is 15 $\frac{3}{4}$ in. long, 5 in. high and 7 $\frac{3}{4}$ in. wide. It is cored-in such a way as to present a flat, unbroken surface for the horizontal mortar. It is made in gang molds on cars. The units can be made face up or face down, as the manufacturer chooses, and of a desirable consistency.



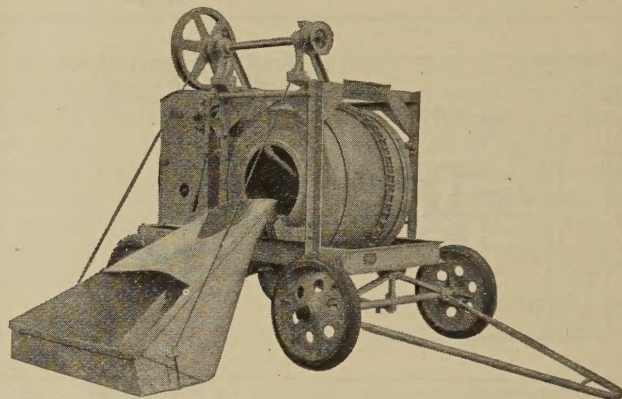
A stiff mud mixture, which is the best mixture, would undoubtedly require some puddling in the molds. A slightly wetter mixture would run around the cores without puddling. The dimensions of the gang mold car are 4 ft. 1 $\frac{1}{2}$ in. in width, 7 ft. 8 in. long, the height above the rail varying with the unit. Some of the cars produce 64 units, 5 in. x 8 in. x 12 in.; 48 units, 5 in. x 8 in. x 16 in.; 32 units, 5 in. x 8 in. x 24 in.; 48, 5 in. x 12 in. x 16 in.; 32, 5 in. x 12 in. x 24 in. A typical unit and the mold car are both shown in the accompanying illustration.

New Rex Mixers

Two new models of Rex mixers have been announced by the Chain Belt Co. of Milwaukee, a half-bag mixer to be known as the Rex 234-S, and a one-bag machine, the Rex 237-S. Both are the so-called low-charging types and can be equipped with either a hinged platform or charging skip.

In the drum the mixing blades and buckets have been specially arranged to decrease the time required for discharging the batch, no matter what mixing proportions are used. The opposite side discharge control is of an entirely new design to make the operation of the chute easier. The power charging skip has been constructed so as to reduce the time of charging the drum.

The new Rex models have been made very compact and sturdy. The shorter wheel-base makes them more readily portable, especially in close quarters. An adjustable malleable jack placed on the charging end of the axle gives the mixer 4-points suspension while mixing concrete.



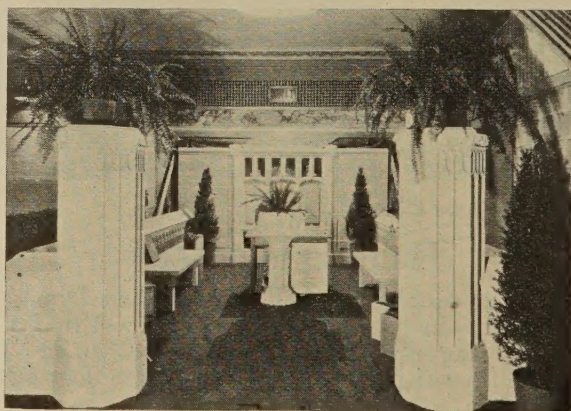
An asbestos disc type of clutch has superseded the old wood block type. Self-oiling bushings are provided in the drum rollers which are of malleable iron construction.

The Rex 237-S is equipped with an 8 H.P. 2-cylinder vertical, hopper-cooled Le Roi Engine having a high-tension magneto, an automobile type carburetor and a throttling governor. On the Rex 234-S a 4 H.P. vertical gasoline engine is used.

Either machine can be equipped with a hinged low-charging platform which folds up while traveling, or a power charging skip. Rubber tired disc wheels or built up steel wheels are optional equipment. The disc wheels are equipped with phosphor bronze bushings to allow faster traveling over city streets.

At Cleveland Show

George Rackle & Sons Co., for many years among the foremost manufacturers of concrete trim stone, made an exhibit of white cement finished stone by



DISPLAY OF WHITE CEMENT AND TRIM STONE AT CLEVELAND SHOW

cooperative arrangements with the Sandusky Cement Co., at the Cleveland Better Homes Exposition, in April. The attractiveness of the display is shown by the picture.

Organizations

American Concrete Institute; Harvey Whipple, Secretary, 1807 East Grand Boulevard, Detroit. Convention February 25 to 28, incl., 1924, in Chicago.

American Concrete Pipe Association; M. W. Loving, Secretary, 111 West Washington St., Chicago.

American Engineering Standards Commission; Dr. P. G. Agnew, Secretary, 29 W. Thirty-ninth Street, New York City.

Associated General Contractors of America; G. W. Buchholz, Secretary, 1038 Munsey Bldg., Washington, D. C.

Associated Metal Lath Manufacturers; 123 W. Madison St., Chicago; Wharton Clay, Commissioner.

Building Officials Conference; Rudolph P. Miller, President, Fred W. Lumis, City Hall, Springfield, Mass., Secretary.

Iowa Cement Stave Silo Association; H. E. Kilmer, Secretary, Oskaloosa, Ia.

Iowa Concrete Products Association; Ross Dowell, Secretary, 405 Hubbell Bldg., Des Moines.

Mid-West Concrete Products Association; D. R. Donlen, Secretary-Treasurer, 4340 Marcy St., Omaha, Neb.

National Association of Manufacturers; John E. Edgerton, President; Henry Abbott, Treasurer; George S. Boudinot, Secretary, 50 Church St., New York City.

The National Concrete Stave Silo Association; W. G. Kaiser, Secretary, 111 West Washington St., Chicago.

National Crushed Stone Association; A. P. Sandles, Secretary, 405 Hartman Bldg., Columbus, Ohio.

National Housing Association; Lawrence Veiller, Secretary and Director, 105 East 22nd St., N. Y. C.

The National Lime Association; Mather Bldg., Washington, D. C.

Fifth Annual Convention, Hotel Commodore, New York city, June 13, 14, 15, 1923.

National Sand and Gravel Producers' Association; T. R. Borrows, Acting Secretary, 903 Munsey Bldg., Washington, D. C.

Portland Cement Association; William M. Kinney, General Manager, 111 West Washington Street, Chicago.

Wisconsin Concrete Products Association; D. R. Collins, Secretary-Treasurer, Milwaukee.

Trade Publications

A circular of Gifford-Wood Co. announces the new G-W Electric Capstan Car Puller as a means to easier spotting of cars. It has a rope speed of 44 ft. per minute, and on a smooth, level track can pull two loaded cars of 75 tons total weight each or seven empty cars of 25 tons each.

Shope Concrete Brick, Its Origin, Use and Methods of Manufacture, Shope Brick Company, Portland, Ore., a new catalog of 40 pages and cover, 9 $\frac{3}{4}$ in. x 6 $\frac{3}{4}$ in., giving an impressive array of illustrations and testimonials of the satisfactory use of Shope brick. There are numerous color plates showing textures and tints in which brick are made, and many pictures of the buildings in which they have been employed. A good deal of interesting data is also presented as to strength, absorption, and so on.

Ideal Hoists, Universal Hoist & Mfg. Co., Cedar Falls, Iowa, a circular describing and illustrating in detail, both in its parts and in its use on the job, reversible and non-reversible Ideal Hoists, for use as the manufacturers say "any place where there is a rope or cable to pull." The producers place particular emphasis upon the simplicity of the equipment and stand ready to furnish more detailed information as to the hoist for any particular kind of work.

Steel Curb and Gutter Forms, Heltzel Steel Form & Iron Co., Warren, Ohio, a circular describing the use of Heltzel steel forms in construction of concrete curbs and combined concrete curb and gutter. The curb and gutter forms are made in any depth with removable templates, adjustable stakes and standard Heltzel rails.

Samson Concrete Wall Construction, Samson Concrete Wall Co., 717 East 140th St., New York city. This is a circular describing a system devised by Albert Oliver & Son with Fred C. Fowler as consulting engineer—a type of dwelling house construction similar in many ways to work which has been done with the Cement Gun over a wood frame, the frame work being sufficient to carry the metal fabric to which the supporting concrete is applied. In this case, the fabric is Samson Welded Wire Sheathing and the equipment for applying the stucco or concrete is the Hodges stucco machine. The circular gives details of the construction.

Austin Portable Gyratory Crushing and Screening Plants, Bulletin No. 30, Austin Manufacturing Co., 400 North Michigan Blvd., Chicago, Ill.; 12 pages and cover, 6x9; illustrating and describing portable gyratory crusher outfit for use in road building and other work in the proper reduction and handling of aggregates. The bulletin also includes descriptive matter on portable bins and screens and other special road building equipment.

Hy-Rib Concrete Sidings and Roofs for Timber Framed Buildings, an 8-page circular of the Truscon Steel Co., Youngstown, O., descriptive of the use on industrial and other buildings of Hy-Rib metal lath stuccoed for walls and concreted for roofs, with back-plastering on the walls between studs. The circular recommends a framing consisting of 2x4 or 2x6 studding on 24-in. centers, with $\frac{3}{8}$ -in. Hy-Rib fastened with nails and staples to ribs running horizontally, and plastered on the outside with scratch and finish coats of cement mortar (cement 5 parts, sand 12 parts, lime paste 1 part). For roofs, similar material is used, with rafters on 24-in. centers, covered with concrete to a thickness of 1 $\frac{1}{2}$ in. and plastered on the under side. The circular shows details of the work described.

Lock Block, Concrete Block Machine Co., 111 Hamilton St., Newark, N. J., a circular describing and illustrating a building unit having top and end interlocking features, produced in tamp machines of the face-down type.

Daylighting Schools is the subject of the latest Truscon publication on steel windows just issued by the Truscon Steel Co., Youngstown, Ohio. The lead article in this booklet is by John J. Donovan, one of the foremost school architects in the country. His authoritative discussion on the vital relationship of windows to school construction makes the booklet of unusual interest to architects. The important conclusion drawn from critical studies conducted in 216 class rooms of 31 different schools over a period of 5 school semesters, as contained in the report of air conditioning made by the New York State Commission on ventilation, is to the effect that window ventilation appeared to be the most promising method of class room ventilation.

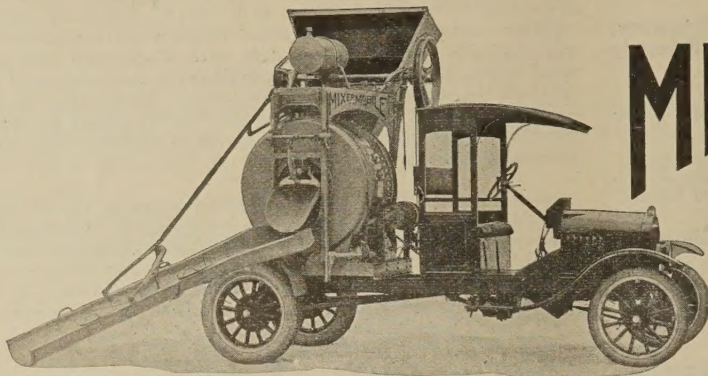
The booklet, 8 $\frac{1}{2}$ in. x 11 in. with 28 pages is filled with illustrations and vital information about steel windows that are adaptable for school construction.

In mention of the *Batcherplant* catalog in the May issue of CONCRETE the name of the manufacturers of this equipment, the Blaw-Knox Co., Pittsburgh, was omitted. The publication has 32 pages, describing and illustrating very profusely construction jobs calling for equipment of this kind. The publication points out reasons for its development: (1) requirements of state and engineer's specifications for the accurate measurement of sand and stone; (2) the necessity for a central proportioning plant as a part of modern road building and concrete construction to cut costs and speed up the measurement of aggregates. This equipment was used in 1922 construction season on more than 150 construction jobs in 28 different states. The publication is of unusual interest; the equipment itself is of the suspension bin type for one-man operation.

Walter Concretile, fundamental facts about the concrete roofing tile industry, Crawfordsville Foundry Co., Indianapolis; a circular describing in detail the conditions of the general roofing market and the opportunities for concrete roof tile. Also describing in detail the Concretile trowel bar, which has features for ease in handling, rapidity in making tile, and so on, which are especially recommended by the producers; and describing also the features of the new Walter Concretile pallet with the cleats to prevent slipping, and with the further detail of the proper method of laying Walter Concretile on the roof.

Godwin Steel Paving Guards are the subject matter of a circular of 8 pages covering testimonials and illustrations of the use of Godwin paving guards at the edges of rails in street pavements and at other critical edges in street paving in a number of localities. The Godwin steel paving guard is intended to reinforce a pavement at its weakest point, the edge. It is a kind of retaining wall of steel anchored in the paving itself and seals the edge of the road and protects it from disintegration.

The Alexander Milburn Co., 1416-1418 West Baltimore St., Baltimore, Md. A small catalog describing and illustrating Milburn acetylene generators and compressing plants, Milburn welding and cutting torches and auxiliary equipment.



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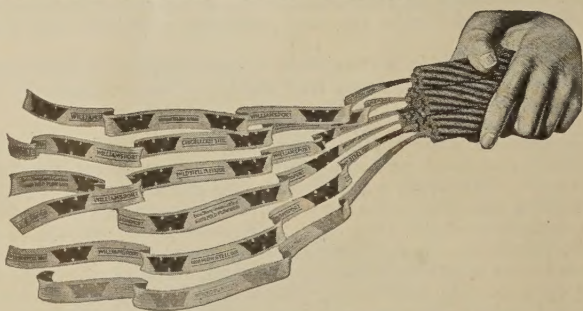
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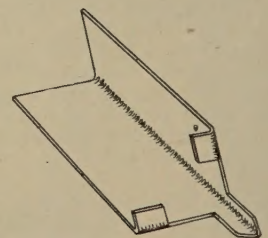
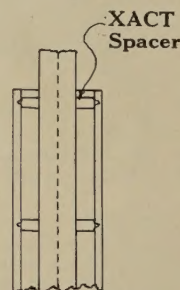
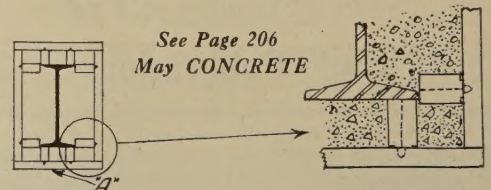
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